ORTHODOXAL
NAVIGATION.
OR,
The Admirable and excellent ART of
ARITHMETICALL
GREAT CIRCLE-SAILING,
Inlarged and applied to places of all
SITUATIONS,
And many difficulties removed, and sundry things
now added, that were never published before.

Whereby, Sailing by an Arch of the great Circle,
extended from any one Place, to any other Place, (where
possible and convenient) is made easie to the under-
standing of those of mean capacity, and ready to
demonstrate with facility, And suiting
with the Marriners haste, by a spee-
dy dispatch, when he hath but
a short opportunity.

Together
with a new and true
PARADOXAL CHART.

By BENIAMIN HUBBARD, late Student of the
Mathematicks in *Charls Towne* in *New-England*.

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23

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23

68d

To the Right Worshipful,

The MASTER, WARDENS, and ASSI-
STANTS of the famous Societie of
TRINITIE HOUSE
in Deptford Strand.

Right Worthy Gentlemen,

AS I have in other parts
and points of *Navi-
gation,* read over (with
diligent heede, and
practise annexed) the
works of our worthy
Country men, that have been famous
in the practise of the Mathematicall
Arts, as Mr. *Blundevile,* Mr. *Wright,*
Mr. *Gellibrand,* and Mr. *Gunter,* with
others:

others : So in this part and point of Sailing by an Arch of a great circle, I have perused these chiefly, Mr. *Davis*, Capt. *Saltonstall*, Mr. *Carpenter* (with *Pitiscus*, whom he cites,) Mr. *Wing*, but I gained most of Mr. *Richard Norwood*.

Yet some things (I must needs say) they either quite omitted, or treated of so obscurely, that my shallow capacity could not understand them, (possibly they had attained to the knowledg of some things, which it pleased them not to give us their best help, that wee might attain unto the same;) which was the occasion of my study, and (through Gods blessing) attainment unto those things I here present unto your Worships for your acceptation, and as you shal think fit for your recommendation of them unto others. I hope you will finde many things herein very useful, and very easie, that were never publish-

ed

d by any before mee; for whereas
Mr. *Davis* intended, (as he ſaith)
write of *Paradoxall Navigation*, and
a *Paradoxal Chart*, (ſo terming it,
becauſe it is beyond opinion, that
ſuch lines ſhould be deſcribed by
plaine horizontal motion,) I neither
now whether he lived to performe
; and if he did, whether he perfor-
med it as I have done it in this book,
or how he meant. But I have ra-
ther called this *Orthodoxal Naviga-*
tion, it being the true opinion in-
deede concerning that Art, which is
fit to be uſed in many long voyages,
not in all.

For certainly, this way here pro-
pounded, together with theſe Charts
or Plats, are moſt uſefull for great
Circle Navigation. The ſeverall
countries with their borders, and
the Sea, and its Coaſts being more
truely laid down for Latitude, Lon-

gitude,

gitude, Rumb, and Diftance in M
cators Plats.

The great circles way from pl
to place, being found out by t
Paradoxall Chart, fhewing the o
liquity of that great circle, and t
Longitudes and Latitudes it p
feth thorow, whereby the Voy
may be pricked downe in a blan
Mercator. And therein you m
fee that the great Circle delinea
the neareft way from place to pla
and the reafon thereof. And t
Diftances may bee taken fpeedil
by the fcale proper thereunto.
alfo the Latitude and Rumbe bei
knowne, the Longitude and D
ftance is found Arithmetically by t
Rules in this Booke for degrees a
minutes.

If therefore you fhall fee caufe
allow thefe your approbation,
will encourage me to tender ma
te

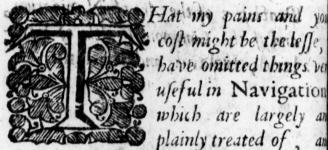rs of farre greater concernment

some convenient way for publick

enefit.

I remaine an unfeigned desirer of the prosperity of your Worshipfull Societie, of the Lovers, Professors, and Practisers of the Art of Navigation, and of the Common-Wealth of England, Ireland, and Scotland.

BENJAMIN HUBBARD.

To

To my much respected Friends, the PRACTISERS and LOVERS of the ART of NAVIGATION.

Gentlemen,

THat my pains and you cost might be the leſſe, I have omitted things very uſeful in Navigation, which are largely and plainly treated of, and demonſtrated by others, (conceiving you are well acquainted with them,) and inſiſted only on the particulars mentioned in the ſubſequent Contents, which are not cleared as yet by any that I know of.

Theſe Additions at the firſt, I intended only for my own private ſatisfaction, and having (through Gods bleſsing) attained unto that which I here tender unto your view, I thought it not meet to with-hold a thing ſo requi-

To the Reader.

requisite and necessary for your furtherance.
Bestow therefore the reading of this small
Treatise, I pray you, and mark how plain and
easie it makes even difficult things. If you
intend to make use of these Rules, it will be
requisite that you get some book, having
in it Artificial Signes and Tangents, both
for ease and speed, (if you have not one
already) as Mr. Gunter's works, or
Mr. Norwoods Doctrine of Triangles, or
his Epitome; and get a large and true Merca-
tors Plat for those parts your voyage is made
in, with its proper Scale; and make also for
your daily use, a blank Mercator Chart of the
same scale, and keep your reckoning thereon.
(Make one for each voyage.) And if you reap
profit thereby, (as you may with ease) give
God the glory af all his gifts. And upon your
acceptation of these, I shall be encouraged to
publish other excellent helps for you; till then,

I remaine a Lover of the Arts Mathe-
maticall, and your friend,
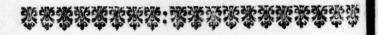
BENJAMIN HUBBARD.

A
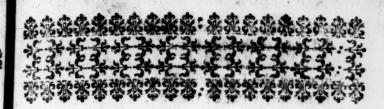
A NOTE.

BE pleased to take notice, that I acknow-
ledg the Figures made by me in this book,
are somewhat defective, not being exactly
drawn, for want of more time, a cleerer eye-
sight, and meet instruments; therefore they
must bee corrected by skilfull Artists. Yet
as they bee, they are demonstrative for the
uses intended; and the Rules doe inform
you how to amend any of them, which o-
ther Artists have not long since written large-
ly of.

Your friend, *B. H.*

The

The Author to the friendly Reader.

1. IF Husbandry which did begin
    in the first *Adam's* time,
And towards its perfection,
    in every age did climbe;
2. Some rich, some poor, adding what they
    had by experience gain'd ,
And yet hath not even at this day,
    her highest pitch attain'd :

3. Then need none marvell very much
    if Navigation,
That came so late into the world,
    has not perfection.
4 And yet this rare and usefull Art,
    (as plainly doth appear)
Hath got most wonderful increase
    in the last hundred year.

5. As though it were Gods will and mind
    this Art should overtake
That which set out so long before,
    her journey for to make ;
6. And by the way did meet withall,
    so many helpers true,

Whereas this Art, (compar'd with them,)
    did meet with very few.

7. But when the Lord will shew himselfe
    in means, what e'r they be,
Then shall strange things and wonderful
    appear casie to see.
8. And those that read over this book,
    shall see it there appear,
That for great circle Sailing now
    perfection is near.

9. The greater part of this small book
    you shall find to be new;
And all the Rules therein (I hope)
    you shall find very true.
10. But if for any thing therein,
    a better Rule you find,
Publish it with all speed (I pray)
    so shall you please my mind.

The

The CONTENTS of the CHAPTERS in this Booke.

The Contents.

CHAP.

A PARADOXALL N.P.H

80

77

60

50

40

30

80

80°

70°

60°

50°

40°

3°

20°

10°

A

30

310

320   330   340   5

In this Paradoxal Chart, the Angle at H a
marked also with NP.

The lower side from B to A represents a q
noctiall Line.

The side B H. part of the Meridian at Lon
The side A H part of the Meridian at Lon
And by the sides B H and A H are fi
with their Parallels, The Tropick of *Cancer*
Artick Circle at 66 deg. 30 min.

Then from the Angle B to the Meridia
great Circles.

I applied it to these degrees of Longitude
the Superficies of the Terrestriall Globe,
most frequently made.

28

1a

A

30

20

10

550   360

t H above reprefents the North Pole,

s a quarter of the Equator, or Equi-

Longitude 300 degrees.
Longitude 30.
re figured the degrees of Latitude,
ncer, at 23 deg. 30 min. And the

ridian A H there be 18 Arches of

itude containing that eighth part of
be, wherein long voyages are now

ORTHODOXAL
NAVIGATION.

CHAP. I.

f all the Circles ufually drawne upon the Terreftrial Globe, both fmall and great.

That at the firft wee may the better underftand what is meant by a great Circle, I will firft fhew what circles are drawne upon the Globe, and what a great Circle is, in the fenfe it is ufed in the Art of *Navigation* : And then how it manifeftly appears that a great circle drawes a nearer way from place to place, then a leffer circle can doe.

1. The
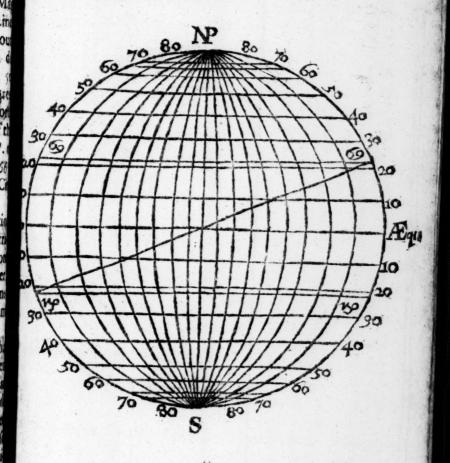
1. The small Circles usually drawne upon a Terrestriall Globe, are twenty in number, and of ten severall Magnitudes: for there are the same number, and one to one of the same Magnitude, on each side of the Equinoctiall Line, as well towards the North, as towards the South Pole. Namely, eight Parallels for every ten degrees of North Latitude, *viz.* 10, 20, 30, 40, 50, 60, 70 80. And as many for every ten degrees of South Latitude. Then 23 deg. 30' of North Latitude, is the Tropique of ♋. and 66 d. 30' of the same Latitude is the Artique circle. And 23 d 30'. of South Latitude, is the Tropique of ♑. And 66 d 30'. of South Latitude, is the Antartique Circle.

These twenty smaller Circles in the description of the Globe in *Plano*, are sometimes demonstrated by bowing lines, sometimes by circles one within another, the Pole being the Center, and sometimes by strait lines, which are Diameters to those circles, as in the following Diagram may appear.

The great circles usually described upon the Globe, are also twenty in number, all of them of the same Magnitude, *viz.* eighteen Meridian circles. The visible part of each circle (to those that be under the Equinoctial line,) being placed at 10. d. distance from the former, they reaching 180 deg. of Longitude, The other Semicircles, or unseen parts of the same eighteen circles, compleating the number of 360 d. of Longitude, Then the Equinoctial Line; and the Ecliptique line, make the number of 20. great Circles.

The
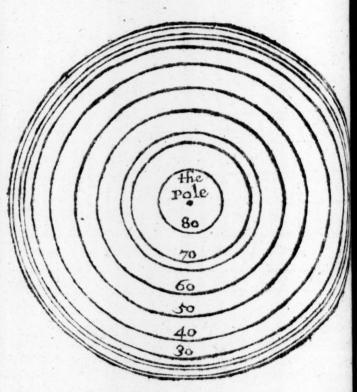
These in a demonſtration in *Plano* , are deſcri-
ed by ſtreight lines, bowing lines , and one great
circle, as appears in this Example.

This

This Figure following shews the proportionsble Magnitude of all the Circles usually described on the Terrestriall Globe.

the
Pole
.
80

70

60

50

40
30

For the outmost Circle is the Magnitude of all the great Circles, and the ten lesser circles are made by the Diameters or Parallels from the Equator Northward, in the former Diagram, viz. 1. The parallel of 10.ᵈ. Lat. 2. of 20.ᵈ. Lat. 3. the Tropique of Cancer. 4 of 30.ᵈ. of Lat. &c. the ninth circle being the Artique circle. The tenth a parallel

of 80ᵈ. Lat. there being alſo 10 circles of the ſame Magnitude South-ward from the Equator.
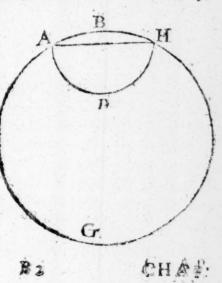
3. Now a great circle in the ſenſe here uſed, is either a Meridian, the Equator, or the Ecliptique Circle, or ſome other Circle of the ſame Magnitude, having obliquity more or leſſe, as the Longitudes and Latitudes of the two places propounded to require.

4. To evince that a great circle leads a neerer way from place to place then a leſſer circle can do; I will thus demonſtrate it. The Globe being every way round as a ball, let a great circle compaſſing it be repreſented by the circle, A B H G.

A ſtraight line cannot be drawne from one place to another of any great diſtance, for that would paſſe under ſome part of the ſuperficies of the earth or ſea, as a needle being thruſt through the ſide of a ball, as the line A H ſhewes: Nor an Arch of a ſmaller circle the neerer way, (though a parallel of the ſame Latitude) but the ſmaller the circle is, the further about it goes, as the leſſer circles Arch marked with A D H. But the neereſt way from A to H being above Earth and Water, is the Arch of the great Circle repreſented A B H.

CHAP.

CHAP. II.

Of all the severall sorts of Situations of Places that can be; And how to contrive and draw the Arch of a great Circle, passing the neerest way from any one Place, to any other (there being any great quantity of distance betwixt them) their Longitudes and Latitudes known.

1. THere be foure and twenty severall sorts of Situations of two places, in respect of the distance to be exactly taken betwixt them, *viz.*

Seven under the same Meridian.

Six under the Equinoctial Line.

Three, one of the two places being under the Equator; the other in some Latitude, they being under several Meridians.

Eight, both places having Latitude, they being under several Meridians.

Of Places under the same Meridian,

I. Some of them have the same Longitude.

Sit. 1. One place having no Latitude, and the other hath Latitude.

2. One place having North Latitude, and the other South Latitude. 3. Both

t. 3. Both places having North Latitude, or both South Latitude.

III. Some of them, one place hath 180 d. of Longitude more then the other.

Two places both having Latitude toward the same Pole, whether North or South.

One place having North Latitude, and the other South; both Latitudes being just of the same quantity.

One place having North Latitude, and the other South Latitude, but of different quantities of Latitude, or one more Latitude then the other.

One place having no Latitude at all, and the other having Latitude.

Of Places, both being under the Equator.

III. 1. Some of them, One of the places hath no Longitude.

The other hath Longitude, lesse then 180 d.

Or the other hath Longitude just 180 d.

Or else the other hath Longitude more then 180 degrees.

IIII. 2. Some of them, Both the places have Longitude.

But the difference found betwixt their Longitudes, is either lesse then 180 deg.

Or the difference of Longitudes is just 180 d.

Or else the difference of Longitudes betwixt them, is more then 180 degrees.

V. Of Places, one of them being under the Equator, the other in some Latitude, they being under several Meridians. The difference of Longitude betwixt the places, being less then 90 deg.

*Sit.*15. Or the difference of Longit. being juſt 90

16. Or elſe the difference of Longitude being mor
then 90 degrees.

VI. Of places, of which neither of the two
be under the Equator, they being alſo und
ſeveral Meridians.

17. 1. Some of theſe, One place hath North Lati
tude, the other hath South Latitude.
Both their Latitudes being of one quantity.

18. Or their Latitudes being of different quantities
and the difference betwixt their Longitudes being
leſſe then 90 ᵈ.

19. Or their Latitudes of different quantities, and
the difference betwixt their Longitude juſt 90

20. Or elſe their Latitudes of different quantities
and the difference betwixt their Longitudes be
ing more then 90 degrees.

21. 2. Some of theſe, Both places have North La
titude, or both South Latitude.
Both the Latitudes of the ſame quantity, and having
leſs then 180 deg, difference of Longitude.

22. Or, Two places having different quantities
of Latitude, and difference of Longitude, leſ
then 90 deg.

23. Or their Latitudes different quantities, and
having difference of longtude juſt 90 degrees.

24. Or elſe, their Latitudes of different quanti
ties, and difference of Longitude more then 90

Thus having pointed at the ſeveral Situations of
places, (for more full intelligence of them, read
this Chapter, and the next.)

Now I come to ſhew how a great Circle
may bee contrived, drawne and demonſtrated
which

hich shall passe from place to place, the
ne Longitudes and Latitudes of the places being
ven.

And here observe that some sorts are easie to re-
esent so, and some sorts are difficult.

1. Of those Situations that are easie.

   1. Any two places that differ onely in their
     Latitudes, and have both the same de-
     gree and minute of Longitude, or one
     just 180 degrees of Longitude, difference
     from the other, the Meridian is a great cir-
     cle, that passeth directly over both those
     places.

   2. Any two places that differ only in Longitude,
     and have no Latitude at all. The Equator
     (called also the Equinoctial Line,) is a great
     circle that passeth directly over both those
     places.

     These imply the first 13 Situations.

2. All other Situations of places are somewhat dif-
ficult to finde out, contrive, and demonstrate the
great circle that wil pass directly over the two pla-
ces.

For the better understanding how to draw a great
circle over any two places in the last eleven Situati-
ons, mark these few and easie Rules.

Rule 1. That every great Circle, except the Equi-
noctial Line, do cross the Equinoctial Line in two
opposite points; so the Ecliptique line being a great
Circle, crosseth the Equinoctial line, in the opposite
points, called the head *Aries* and *Libra*.

Rule 2. That 90 degrees from each of those points

of

of the great Circles interſection, or croſſing th
Equinoctial Line, is the point of the greateſt Obl
quity of that great Circle, or its greateſt inclin
tion toward the pole, or declination from the E
quinoctial line : ſo the greateſt obliquity of the E
cliptique line, is 23 ᵈ. 30 ' at the head of ♋ a
♑, which points ſo called are 90 degrees in Long
tude from the points called the head of *Aries* an
Libra where the Ecliptique line interſecteth an
croſſeth the Equinoctial line.

3. That one half of every great Circle, exce
the Equinoctial line, inclines towards the Nor
Pole, and the other Semicircle thereof inclines
ward the South Pole; ſo halfe the Ecliptick li
containing the Signes, *Aries, Taurus, Gemini, Ca*
cer, Leo and *Virgo* incline toward the North; an
the other Semicircle thereof containing the ſig
Libra, Scorpio, Sagittarius, Capricornus, Aquari
and *Piſces* incline toward the South.

4. That the North Obliquity, and the South o
liquity of the ſame great Circle is of the ſam
quantity, one point of its obliquity being Diame
trically oppoſite to the other, ſo the point call
the head of ♋ is in the point of the greateſt obliqu
ty of the Ecliptique, or its greateſt declinatio
Northward, 23 ᵈ. 30 ', and the head of ♑ is in th
point of its South obliquity, or greateſt declinatio
Southward, which alſo is 23 ᵈ. 30 ' and diamet
cally oppoſite to the other point of Obliquity.

5. That 180 degrees of Longitude from a poi
in any part of a great Circle, doth bring to a poi
diametrically oppoſite to the former point, whe
the 180 degrees began; that is to ſay, to a poi

n the fame degree and minute of South Latitude as
the other point had of North Latitude , or to the
fame quantity of North Latitude, as the other had
of South Latitude : fo the point in the Ecliptique
called the head of ♉ being in North Latitude 11. d.
30'. And 180 d. of Longitude from that point,
brings to the point called the head of ♏ being in
South Latitude 11 deg. 30'. and is diametrically op-
pofite to the head of ♉; for a ftreight line called a
diameter to a circle will touch both of them , they
placed in the Circle.
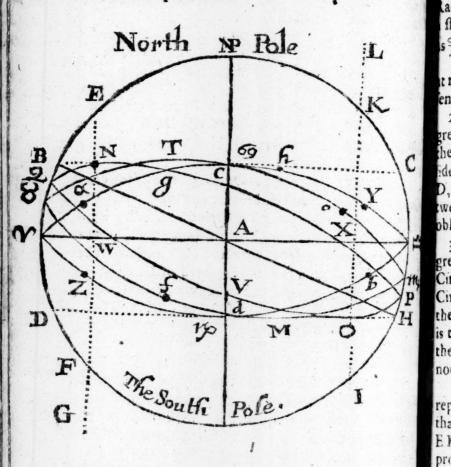
6. Thefe things are evidently cleer by the true
ufe of the Terreftrial Globe , for obferving the
Meridians paffing through the head of *Aries* , and
turning the Globe 180 deg. of Longitude, is the
head of ♎, and fo from the head of *Taurus* to the
head of *Scorpio*; and fo from the head of *Cancer* , to
the head of ♑, is juft 180 degrees of Longitude,
and each of the two laft points 23 deg. 30' Lati-
tude one toward the North, the other toward the
South.

Yet wee may alfo demonftrate the fame
paffages of great Circles in *Plano* , in fome
fort in the following Diagram , (and more
exactly , for one quadrant thereof , in the
Paradoxal Chart , in the fifth Chapter of this
Booke ,) wherein the Circle E F I K
and the Perpendicular Line reprefent the Meridi-
ans.

The ftrait Line ♈ A ♎ reprefents the Equinoctial
Line, called alfo the Equator.

The

The ftrait Line B A H, and the Arches reprefent the Ecliptick line.

This DIAGRAM hath onely Meridians, the Equator, and the Ecliptick Circles, which wee may thus demonftrate, and alfo any other great Circle in the fame manner as the Ecliptick, of what quantity of Obliquitie fo ever it be.

3. To

3. To make such a demonstration: First, by the Radius of your scale, make a circle E K I F, and draw a strait line through the Center perpendicularly, as ♋ A ♑, and these are Meridians.

Then draw another strait line crossing the former at right angles, as *Aries* A *Libra*, and this represents the Equator.

2. Then consider the Obliquity of any other great circle you would draw, as if it be, 23 d 30'. as the Eclipticke hath; Then set off 23 d 30'. on each side of the Equator, as from the figure *Aries* to B and D, and from the figure *Libra*, to C and H, and make two dark lines for the bounds of that great Circles obliquity, as B *Cancer* C, and D *Capricorn* H.

3. If the Circle E K I F be the Meridian of the greatest obliquity of the propounded great Circle, 23 d 30'. Then is the propounded great Circle represented by the strait line B A H. And the strait perpendicular line *Cancer* A *Capricorn* is the Meridian of the Intersection, or crossing of the propounded Circle, with the Equator or Equinoctial Line.

4. If the perpendicular line *Cancer* A *Capricorn* represent the Meridian of the greatest Obliquity of that great Circle propounded, Then the Circle E K I F, is the Meridian of the Intersection of the propounded great Circle *Aries, Cancer, Libra, Capricorn* with the Equator. Therefore draw the Arches of that great Circle with such extent as will touch the points *Aries, Libra* and *Cancer*, in the line of Obliquity. And so also on the other side *Libra, Capricorn* and *Aries*.

5. If two several Latitudes of the propounded great

great Circle be given, with the difference of Longitude betwixt them. Put the lesse Latitude, and its equal quantitie opposite thereunto (by the fifth Rule) in the Circle E K I F. As one place North Latitude 11 deg. 30'. the other North Latitude 11 deg. 12' and difference of Longitude 94 deg. 18. Then set off 11 deg. 30'. Latitude from *Aries* to *Taurus* in the Meridian E K I F, and so again from *Libra* to *Scorpio*, and make an Arch from *Taurus* touching the great Circles Obliquity at T, unto *Scorpio*, and so also from *Scorpio*, by M to ♉, and this also represents the Ecliptique Circle.

6. If two places be propounded both in one quantity of Latitude toward the same Pole, one just 90 deg. of Longitude from the other, then is the greatest obliquity just in the midst betwixt them; therefore 45 deg. from the Equator, at *Aries* and *Libra* in the outward Circle make markes, and by them draw long perpendicular lines E F G and I K L. As North Latitude 17 deg. 5'. North Latitude 17 deg. 5' difference of Longitude 90 deg. Then open your compasses to the Latitude propounded 17. deg. 5' and set it off from *Aries* to Q and from *Libra* to P. also make a marke at the same distance from the Center at S and V. Then one foot of the compasses standing on the perpendicular E F, and make the Arch Q N; and on the perpendicular I K, make the Arch P O.

Then extend the compasses, one foot standing on the perpendicular line E F G till the other will reach the markes N S P. And againe in the perpendicular I K L, till it reacheth the marks O U U Q. so shal the curved lines, or the Arches marked Q N, N S P,

S P, P O, O V Q. or Q N S P O V Q represent
e Ecliptique Line , the Obliquity of it being at
e points by N and O 45 deg. of Longitude from
e outward Meridian B C D H (as appears by the
erpendiculars E F and I K, there being 45 ^{d}. from
Aries to E, and so to F. and likewise from *Libra*
K, and so to I) and Q S is North Latitude 17
eg. 5'. and P V is South Latitude 17 deg. 5', in
e outmost and middle Meridians.

And because the obliquity is 45 deg. from each
f those Meridians, therefore the same great Circle
tersects the Equator at 45 deg. also of Longitude
om the said Meridians ; for it must do so at 90
egrees from the greatest Obliquity by the second
ule.

Now in such a Diagram, all the 24 Situations be-
re mentioned are implyed.

4. Therefore I wil shew how all the before pro-
ounded several Situations may be found in the pre-
dent demonstration page 20.

Yet I wil now only number the Situations , and
ew by what Marks and Letters the 24 situations in
e great Circles are demonstrated , because I
ust in the next Chapter speake more punctually of
em. Therefore to propound now where one
xample of each situation is set out in the said Fi-
ure.

The first seven Situations being under the same
eridian, are all in the outward Circle E F I K.
he first Situation is set out by ♈ B. The second
tuation by B D. The third Situation by ♉ B. The
rth Situation by B C. The fifth Situation by B H
he sixth Situation by B P. The seventh Situation

is set out by the figure *Aries* and C.

The six next Situations being under the Equinoct al Line, are all in the strait line representing it, marked by the figures *Aries* A *Libra.*

The eight Situation is represented by *Aries* W The ninth Situation by *Aries, Libra.* The tenth Situation by *Aries, Libra*, X, (because this line represents a whole Circle, 180 deg. reaching from *Aries* to *Libra*; the other half is in returning back to *Aries* again.) The 11 Situation is set out by W A. The 12 Situation by W *Libra* X (that is the Longitude from W to *Libra*, and then back to X 180 deg.) The 13 Situation by W *Libra* A 225 deg.

The 11 half Situations are set forth by examples of places under the Ecliptick line.

The 14 Situation by *Aries a.* The 15 Situation by *Aries, Cancer.* The 16 Situation by *Libra a.* The 17 Situation by ♏ *e;* The 18 Situation by *Taurus f* The 19 Situation by *Taurus d.* The 20 Sit. by T The 21 Situation by *g h.* The 22 Sit. by *Taurus* The 23 Sit. by *Taurus c.* The 24 Sit. by *Scorpio f* And that the Diagram might demonstrate all sort of Situations, the point of the Equinoctial line marked with ♈, is used for that point of the Equinoctial which the Meredian requires.

Now the circle E F I K, represents 1. any Meridian in the first 7 Situations, and the perpendicular always represents a Meridian 90 d. of Longit. from it.

2. That circle represents the Meridian, that Intersects the Equator, and Ecliptick in the points *Aries* and *Libra* in these Situations, 8, 9, 10, 11, 12, 13, 14, 15, 16. and the 21. And then the Ecliptick line is represented by the Circle *Aries a g Cancer h* ♈ *Libra b Taurus Z.*

3. The

3. The same circle also represents the Meridian that Intersects the Equator and Ecliptique line in the head of *Taurus* and *Scorpio*, in these Situations 17,18,19,20,22,23,24. And then the Ecliptick line represented by the circle, *Tau. T c e Scor. M f.*

4. Lastly, it represents that Meridian that cuts the Æquinoctial Line 45 deg. of Longitude from the head of *Aries*, the Ecliptick Circle being marked in that case with Q N S P O V.

Now all these examples to the Rules, and to the several sorts of Situations, are propounded either under one and the same Meridian, as the 7 first, or under the Equator as the six next, or else under the Ecliptick, as all the rest. And I have made choice of Examples of places under the Ecliptick circle, for the last 11 Situations; because all those that understand the use of the Globe, and have diligently observed the Ecliptick line thereupon, or that can demonstrate the Sphere in *Plano*, and therein lay downe the Ecliptick line all the foure wayes expressed in the Diagram; all those I hope, will be able to contrive, draw and demonstrate a great Circle of any Obliquity; and consequently (in the same manner) such a great Circle as will passe directly over any two places propounded, their true Longitudes and Latitudes being known. And wherein such a great Circles passing over any two Places differ from the Ecliptick line is noted afterward.

· CHAP.

CHAP. III.

*How to find the great Circle Distance be-
twixt any two places, howsoever situ-
ate, having the true Longitude and
Latitude of each place.*

THe exact quantity of great Circle Distance be-
twixt any two places propounded with their
true Longitudes and Latitudes, may bee found by
one of these following Rules, according to the ex-
amples annexed; wherein I will follow the Order of
the several Situations propounded before, (ex-
cept the 19 and 23 Situations, whose Obliquity is
first to be found before the great Circle Distance:
Therefore you shal have Rules how to finde the
Obliquity of the great Circle, and the true distance
of places of those Situations in the end of the next
Chapter.) And for all other things ye must work
them, as in other Situations.

I. *Of Places having the same Degree and Mi-
nute of Longitude.*

Sit. 1. One place having no Latitude, the other
having Latitude (whether North or South, 23 deg.
30'. The quantity of Latitude of that place that
hath Latitude, *viz.* 23 deg. 30', is the true di-
stance.

Sit. 2. One place having North Latitude 23 ᵈ. the other South Latitude 23 ᵈ. 30 ʹ. (or any other knowne quantity,) add the Latitudes together, and the fumme of both Latitudes , *viz.* 47 ᵈ. the true great Circle diftance betwixt thofe places.

Sit. 3. Both the places having North Latitude, or both South Latitude; as one in North Latitude 11 ᵈ. 30 ʹ. the other in North Latitude 23 ᵈ. 30 ʹ. take the leffe quantity of Latitude 11 ᵈ. 30 ʹ. out of the greater Latitude 23 ᵈ. 30 ʹ. And there remains 12 deg. the true great Circle diftance betwixt thofe places.

II. *Of Places of which one hath* 180 ᵈ. *of Longitude more then the other.*

Sit. 4. Both Places having South Latitude , or both North Latitude, (whether of the fame quantity or not,) as if both the places be in North Latitude 23 deg. 30 ʹ. Put both the Latitudes together (whether they be equal one to another, or one more then the other) as here 47 deg. and fubtract that number (47 deg.) out of 180 deg. there remains 133 deg. the exact great Circle Diftance betwixt thofe Places.

Sit. 5. Both Places having the fame quantity of Latitude, one Northward, and the other South-ward, then 180 ᵈ. is the true great Circle diftance betwixt thofe places.

Sit. 6. One Place having North Latitude , and the other South Latitude of different quantity , as the Place North Latitude 23 deg. 30 . the other South Latitude 17 deg. 5 ʹ. Take the greater Latitude 23 deg. 30 . out of 180 deg. and there remaines 156 deg. 30 ʹ. to which adde the leffer La-

C titude

ti:ude 17 deg.5 min and that makes 173 deg.35 min
the true great Circle diftance of two places fo S
tuate.

*Sit.*7. One place having no Latitude, and the other
having Latitude. As one place Lat. 00. the other
North Latitude 23 deg. 30 '. Take the Latitude o
that place that hath Latitude out of 180 degree
and there remaines the true diftance : fo 23 deg
30 min taken out of 180 degrees, there remaine
156 deg. 30 min. the true great Circle Diftance
betwixt thofe places. Note alfo, all thefe fe
ven Situations of places, are under the fame Me
ridian. In the three firft Situations, both
the places have the fame degree and minute o
Longitude. In the four next, one of the plac
having juft 180 deg. of Longitude more then th
other.

   III. *Of places, both of them having no Latitude, an*
      one of them no Longitude.

Sit. 8. If the Longitude of that place that had
Longitude be leffe then 180 degrees ; as 28 deg
then that Longitude 28 degrees, is the great Cir
cle diftance betwixt thofe places.

*Sit.*9. If that place that hath Longitude, hath juft
180 deg. of Longitude, then is 180 deg. the true di
ftance betwixt thofe places.

Sit. 10. If the Longitude of that place that hath
Longitude be more then 180 deg. as 208 degrees
Take that Longitude 208 out of 360 degrees, (the
whole Circle of Longitude,) and there remaine
152 degrees, the true great Circle diftance requi
red.

                                    IIII. O

III. *Of Places, both of them having no La-
titude, yet both of them having Longi-
tude.*

Sit. 11. The Rule for thefe is, Take the leffe
Longitude from the greater, and fee what re-
maines for the difference of their Longitudes. And
if there remaine leffe then 180 degrees, that is the
difference of their Longitudes and true diftance:
as one place having 28 deg. of Longitude, the
other 180 deg. Take 28 deg. out of 180 deg. there
remaines 152 deg. the difference of Longitude, and
true diftance betwixt thofe two places.

Sit. 12. If when the leffe Longitude, as 45 deg.
is taken from the greater, as 225 deg. there re-
maines juft 180 degrees; then is 180 degrees
the difference of Longitudes, and the true
great Circle Diftance betwixt two places fo Situ-
ate.

Sit. 13. If when the leffer Longitude is taken
from the greater there remaine more then
180 degrees. As one Longitude 45 degrees,
the other Longitude 270 degrees; Take 45 out
of 270, there remaines 225 degrees. Then take
that Remainder being more then 180 degrees,
viz. 225 degrees out of the whole Circle of
Longitude 360 degrees, and that which remains
then fhall be the true great Circle Diftance,
135 degrees of two places in that Situati-
on.

Note, All thefe 6 Situations of places are un-
der the Equator. The 3 firft Situations, one of
them hath no Longitude. All the other three
have Longitude.

V. *Of Places, one of them having no Latitude, and*
having difference of Longitude lesse then 180 d.

Sit. 14. One place having no Latitude, and the
other any quantity of Latitude, whether North or
South, the difference of their Longitudes found
(by the Rules in Situation 11 and 13. For if when
the lesse Longitude is taken from the greater the
first Remainer be more then 180 degrees, it must
be taken out of 360 degrees, and then the last re-
mainer is the difference of Longitude;) to bee
lesse then 90 degrees.

As one place Latitude 00 d. 00 '. the other Lati-
tude 11 deg. 30 '. the difference of Longitude be-
twixt them, being 27 deg 54 '.

Then finde the distance thus,
As Radius to Cosine of different Lon. 27 d. 54'. 994633
So is the Cosine of the Latitude. 11 d. 30'. 999119
To Cosine of the Distance. 30. 00. 993751

So 30 degrees is the true great Circle Distance be-
twixt two places so situate.

Sit. 15. One place having no Latitude, the other
place having any quantity of Latitude North or
South, the difference of their Longitudes found
(as before) to be just 90 degrees; The true great
Circle distance betwixt those two places is just 90'.
as one place Latitude 00. 00. Longitude 180 d. 00.
The other place Latitude 23 d. 30'. Longitude 270
deg. 00'. Take 180 d. of Lon. out of 270 d. there re-
main 90 d. which is the difference of their longitudes,
and also the true distance required is 90 deg.

Sit. 16. One place having no Latitude, and the
other place having any quantity of Latitude North
or South, the difference of their Longitudes found

(as

(as before) to be more then 90 degrees : As one Place Latitude 00 deg. 00'. the other Latitude 11 deg. 30'. The difference of Longitude betwixt them 152 deg. 6'. Then finde the true great circle distance betwixt those Places thus,

Take the difference of Longitude being more then 90 deg. as 152 deg. 6'. out of 180 deg. there remains 27 deg. 54 min. Then find the distance betwixt two places, one in lat. 00. 00. the other in lat. 11 d 30 m. the difference of their Longitudes being 27 deg. 54 min. as before, that is thus,

As Radius to Cosine of dif. of Long. 27 d. 54'. 994633
So is the Cosine of the Latitude. 11. 30. 999119
To the Cosine of the Distance. 30. 00. 993752

But then take those 30 degrees out of 180 deg. or half a circle, and there remains 150 deg. Which 150 deg. is the true great circle distance betwixt two places, one having no Latitude, and the other 11 deg. 30 min. of Latitude, they having difference of Longitude 152 deg. 6 m.

For as Latitude 00 deg. 00 min. and Latitude 11 deg. 30 min. and the difference of Longitude 27 deg. 54 min. gave the true distance 30 degrees. So Latitude 00 00. and Latitude 11 deg. 30 min. with the complement of that difference of Lon. to 110 d. *viz.* 152 d. 6'. give the complement of that dist. to 180 d. *viz.* 150 deg. for as 27 deg. 54 min. and 152 deg. 6 m. make 180 d. of Longitude; so 30 d. and 150 deg. make 180 degrees of distance.

Because any two points directly opposite one to another upon the Globe, are 180 distant one from the other; therefore seeing 27 deg. 54 min. (the difference of Longitude lesse then 90 deg.) give the

diſtance 30 deg. the Complement of 27 degrees 54 minutes, being 152 deg. 6 min. (the difference of Longitude above 90 degrees) neceſſarily gives the diſtance 150 degrees ; the Complement of 30 deg. For 180 deg. of Longitude in the Equator, (as here it is reckoned, from Lat. 00. to Lat. 00. in the Ecliptick in the oppoſite point) is 180 deg. of diſtance. I have ſpent the more time in ſetting down this *Problem*, becauſe you ſhould underſtand it as well as doe it ; for I conceived it harder to underſtand the reaſon of it, then to work it.

In theſe three laſt Situations, one place of the two hath no Latitude, the other hath Latitude, and difference of Longitude: Situation 14 leſſe then 90 deg. Situation 15 juſt 90. and Situation 16 more then 90 deg.

> VI. *Of any two places ſo Situate, as neither of them both be under the Equinoctial Line, and have alſo difference of Longitude, leſſe then 180. deg.*

Sit. 17. I. Of theſe, One place hath North Latitude, and the other South Latitude.

If the Latitudes be both of the ſame quantity, as one place North Latitude 11 degrees 30 min. and the other Place South Latitude 11 degrees 30 minutes. And the difference of Longitudes betwxt their Longitudes being 55 degrees, 48 minutes.

To finde the true great Circle diſtance betwixt ſuch places, firſt divide the difference of Longitude into two equall parts, and then take one Latitude, and halfe the difference of

Longitude, and finde the diftance belonging to one Latitude; Which doubled, yields the whole Diftance betwixt the places propounded. As Longitude 55 degrees 48 minutes halved, is 27 degrees 54 minutes. Then Latitude oo. oo. and Latitude 11 deg. 30 min. with 27 deg. 54 m. difference of Longitude (being wrought as in the laft Problem) yields the diftance of 30 deg. which 30 deg. being doubled is 60 deg. the whole diftance betwixt one place South Latitude, 11. deg. 30 min. and another place North Latitude 11 deg. 30 min. having 55 deg. 48 m. difference of Longitude.

The Reafon of this Operation, and the exactnefs of it is, becaufe the Latitudes being both of one and the fame quantity, the great Circle paffing the neereft way betwixt thefe two places, doth interfect or croffe over the Equator, juft in the midft both of the difference of their Longitudes, and juft in the midft of their Diftance, *viz.* at 27 degrees, 54 minutes difference of Longitude, and at 30 deg. of diftance.

The whole Diftance therefore betwixt two places, one having North Latitude 11 degrees 30 minutes, the other having South Latitude 11 deg. 30 minutes, the difference betwixt their Longitudes being 55 degrees 48 minutes, is 60 degrees.

Sit. 18. One place having North Latitude, and the other South Latitude of different quantities, and the difference of Longitude betwixt them being leffe then 90 degrees. then find out the true great Circle Diftance by this Rule.

As

As Radius is to the Cosine of the difference of Longitude betwixt them , so is the Cotangent of the greater Latitude to the Tangent of the first Arch ; Which taken from the lesser Latitude and 90 d. added thereto , there remaines the second Arch. Then as Cosine of the first Arch is to Cosine of the second , so is the signe of the greater Latitude to the Cosine of the distance.

As One place in North Latitude 11 deg. 30 min. the other being in South Latitude 16 d. 23 m. the difference of their Longitudes being 70 deg. 25 min.

AsRadius is to the Cosine of dif.Lon. 70ᵈ.25'. 9515..

So is Cotangent of the greater Lat. 16.23. 105316..

To Tangent of the first Arch. 48.54. 100;68..

The lesser Latitude 11 ᵈ. 30'.and 90 d. is 101 deg. 30 m. Out of 101 d. 30 m. take one Arch 48 d. 45 min. and there remains the second Arch 52 d. 45 m.

Then as Cosine of the first Arch 48 ᵈ. 45 '. 9819..

Is to the Cosine of the 2ᵈ Arch. 52. 45. 97819..

So is the sign of the greater Lat. 16. 23. 94503..

{ Add the 2ᵈ. and third sums together, } { and from the fourth substract the first. } 1923:3..

To the Cosine of the Distance. 74ᵈ. 59'. 9413..

So that the true distance betwixt 2 places so situate is 74 deg. 59 min.

Marke, If in this operation, the first Arch being taken from the lesser Latitude , and 90 deg. there shall still remaine above 90 deg then you must take the Complement of that remainder to 180 deg and use that as the second Arch ; and then also in the conclusion, you shall have the Cosine of a number to be taken out of 180 deg, and the Remainder thereof shall be the true great Circle Distance required.

As *Lizard* North Latitude 50 deg. *Brazeel* South Latitude 35 deg. the difference betwixt their Longitudes 58 deg.

As Radius to Cosine of dif. of Longit. 58 d. 972420.

So is the Cotangent of the greater Lat. 50. 992381.

To Tangent of the first Arch. 23. 58 964801.

The lesse Latitude 35 deg. and 90 deg. make 125 deg. take the first Arch 23 d. 58 '. therefrom, and there remains 101 d 2 '. Take this out of 180 d. and there remains 78 deg. 58 min. the second Arch.

Then as Cosine of the first Arch 23 d. 58 '. 996084

So to Cosine of the second Arch. 78. 58. 928189

So is the signe of the greater Lat. 50. 00. 988425

Out of 180 d. 00 '.   1916614

Take   80. 46.   To Cosine, 80 d. 46 min. 920530

Remains 99. 14. the true distance required.

Sit. 19. One place having South Latitude, and the other North Latitude of different quantities, and the difference of Longitude betwixt them; being not 90 degrees; because the great Circles Obliquity is first to be found before the distance, and to finde the Obliquity of the great Circle is the worke of the next Chapter,

Therefore how to finde the great Circle Distance betwixt two places thus Situate, is taught here.

Sit 20. One place having North Latitude, and the other South Latitude, of different quantities, and the difference of Longitude betwixt them being more then 90 d. Then find the true great Circle distance betwixt them thus,

As Radius is to the Cosine of the difference of
Lon.

As Radius is to the Cofine of the difference of
Longitude betwixt them , fo is the Cotangent
of the greater Latitude to the Tangent of the
firft Arch ; Which taken from the leffer Lati-
tude and 90 d. added thereto , there remaines the
fecond Arch. Then as Cofine of the firft Arch
is to Cofine of the fecond , fo is the figne of the
greater Latitude to the Cofine of the diftance.

As One place in North Latitude 11 deg. 30 m.
the other being in South Latitude 16 d. 23 m. the
difference of their Longitudes being 70 deg. 25 m.
As Radius is to the Cofine of dif. Lon. 70 d. 25'. 95.19
So is Cotangent of the greater Lat. 16.23. 10531
To Tangent of the firft Arch. 48.54. 10036
The leffer Latitude 11 d. 30'. and 90 d. is 101 d.
30 m. Out of 101 d. 30 m. take one Arch 48 d. 54
min. and there remains the fecond Arch 52 d. 45
Then as Cofine of the firft Arch 48 d. 45'. 9819

Is to the Cofine of the 2ᵈ Arch. 52. 45. 9781
So is the fign of the greater Lat. 16. 23. 9450
{ Add the 2ᵈ. and third fums together, }
{ and from the fourth fubftract the firft. } 1923.

To the Cofine of the Diftance. 74 d. 59'. 941
So that the true diftance betwixt 2 places fo fituate
is 74 deg. 59 min.

Marke, If in this operation, the firft Arch being
taken from the leffer Latitude , and 90 deg. there
fhall ftill remaine above 90 deg then you muft
take the Complement of that remainder to 180 deg.
and ufe that as the fecond Arch ; and then alfo in
the conclufion, you fhall have the Cofine of a num-
ber to be taken out of 180 deg, and the Remainder
thereof fhall be the true great Circle Diftance re-
quired.

As *Lizard* North Latitude 50 deg. *Brazeel* South Latitude 35 deg. the difference betwixt their Longitudes 58 deg.

Radius to Cosine of dif. of Longit. 58 d. 972420.
is the Cotangent of the greater Lat. 50. 992381.

Tangent of the first Arch. 23. 58 964801.
the lesse Latitude 35 deg. and 90 deg. make 125 deg. take the first Arch 23 d. 58 '. therefrom, and there remains 101 d 2 '. Take this out of 180 d. and there remains 78 deg. 58 min. the second Arch.

Then as Cosine of the first Arch 23 d. 58 '. 996084.

to Cosine of the second Arch. 78. 58. 928189
is the signe of the greater Lat. 50. 00. 988425
out of 180 d. 00 '. } 1916614
take 80. 46. } To Cosine, 80 d. 46 min. 920530
remains 99. 14. the true distance required.

Sit. 19. One place having South Latitude, and the other North Latitude of different quantities, and the difference of Longitude betwixt them; being lt 90 degrees; because the great Circles Obliqui-is first to be found before the distance, and to finde the Obliquity of the great Circle is the worke of the next Chapter,

Therefore how to finde the great Circle distance betwixt two places thus Situate, is taught here.

Sit 20. One place having North Latitude, and the other South Latitude, of different quantities, and the difference of Longitude betwixt them being more then 90 d. Then find the true great Circle distance betwixt them thus,

As Radius is to the Cosine of the difference of
Lon.

Longitude betwixt them, so is the Cotangent of the greater Latitude, to the Tangent the first Arch, which Substracted out of Complement of the lesser Latitude, there maines the second Arch, then as Cosine the first Arch, is to Cosine of the second Arch So is the signe of the greater Latitude to Cosine of an Arch, the Complement whereof to 180 degrees is the true distance betwixt those places so Situate.

As one place in North Latitude 23 deg. 30 the other in South Latitude 11.30. The difference of Longitude betwixt their Meridians being degrees, 54 minutes. Take the Complement the Longitude to 180 degrees, that is, 62 deg. 6 minutes.

As Radius is to Cosine of dif. Lon. 62 d. 6'. 96701
So is Cotangent of the greater Lat. 23. 30. 103616

To Tangent of the first Arch. 47. 6. 100318
The Complement of the lesse Lat. 78. 30.
The first Arch 47 d. 6'. taken ⎫
  out of 78 d. 30'. there Remain ⎬ 31. 24.
                                  ⎭

Therefore the remainder 31 d. 24'. is second Arch
Then, As Cosine of the 1 Arch. 47. 6. 983296
To Cosine of the 2 Arch. 31. 24. 993122
So signe of the greater Latitude. 23. 30. 960069

                                        195319

To the Cosine of 60 degrees.   969899
The complement whereof (to 180 d.) is 120 d. Therefore 120 d. is the true great Circle distance betwixt those places. Note, all these 4 Situations last handled, one hath North Latitude, the other South.

                                        2. The

2. *The 4 Situations following are such as both Places have North Latitude, or both South Latitude.*

t. 21. Two places having the same quantity of ...ude toward the same Pole, the true distance ...xt them is thus found.

...s Radius to Cosine of the Latitude, so is ...igne of halfe the Difference of Longitude, to ...igne of half the distance betwixt them; as if ...places be in North Latitude, 20 deg. 12 min. ...difference of their Longitudes being 64 deg. ...minutes. Then,

Radius to Cosine of the Lat. 20ᵈ. 12ᵐ. 997243
...igne of half the dif. of Lon. 32. 12.' 972662

...signe of half the distance. 30. 00. 969905
...refore 60 deg. is the true distance betwixt two ...es so Situate.

...it. 22. Two places having Latitude toward the ...e Pole, but of different quantity, and the diffe-...e of Longitude betwixt their Meridians being ...e then 90 deg. the distance of one place from the ...er is thus found.

As Radius to the Cosine of the difference of Lon-...nde, so is the Cotangent of the greater Latitude ...the Tangent of the first Arch, which taken from ...Complement of the lesser Latitude, there re-...in the second Arch. Then as Cosine of the first ...ch is to the Cosine of the second Arch, so is the ...ne of the greater Latitude to the Cosine of the ...e Distance. As one place in North Latitude 11 ...g. 30 min. the other in North Latitude 23 deg. ...o min. having difference of Longitude betwixt ...eir Meridians 62 deg 6 min.

As

As Radius to Cosine of dif. Long. 62 ᵈ. 6 ¹. 96

So is Cotangent of greater Lat. 23. 30. 101

To Tangent of the first Arch. 47. 6. 103

Take the first Arch 47 deg. 6 m. out of the plement of the lesser Latitude 11 deg. 30 which is 78 deg. 30 min. and there remaine second Arch 31 deg. 24 min.

Then as Cosine of the first Arch 47 ᵈ. 6 ¹. 98

Is to Cosine of the second Arch. 31. 24. 99

So is signe of the greater Latitude. 23. 30. 96

19

To Cosine of the Distance 60 ᵈ. 00 ¹. 96

Therefore 60 degrees just, of a great Circle the true distance betwixt those two places.

Another Example.

Jerusalem Longit. 66 ᵈ. 00 ¹. North Latit. 31

Babylon. 83. 10. 33

The lesser Longitude 66 taken from the gr Longitude 83 deg. 10 min. and there remains difference of Longitudes betwixt them. 17 d.

As Radius to the Cosine of Lon. 17 d. 10 m. 99

So is Cotangent of greater Lat. 33. 50. 101

To Tangent of the first Arch. 54. 57. 101

Take 54 deg. 57 min. out of the complement 31 deg. 40 min. which is 58 deg. 20 min. there mains 2 Arch 3 deg. 23 min.

Then as Cosine of 1 Arch 54 ᵈ. 57. ¹¹ 975

Is to Cosine of 2 Arch 3. 23. 999

So is sign of greater Latitude 33. 50. 974

197

To Cosine of the true distance 14 ᵈ. 35 ¹. 99

The

fore 14 degrees 35 minutes is the true great
Diſtance betwixt *Jeruſalem* and *Babylon*,
ding to thoſe their Longitudes and Latitudes

. 23. Two places having Latitude toward the
Pole, their Latitudes being of different quan-
and having difference of Longitude juſt 190
es. To find the great Circle Diſtance be-
two places of this Situation is taught in the
Chapter, becauſe the Obliquity of the
Circle muſt firſt bee found as is there ſhew-

. 24. Laſtly, Two places having Latitude to-
the ſame Pole of different quantities, and the
rence of their Longitudes being more then 90
es. To find the great Circle Diſtance betwixt
places, take the complement of the difference
eir Longitudes to 180 deg. And work with
complement Longitude, and the two Lati-
given, as if one of them were North Lati-
, and the other South Latitude, according to
peration in the 18 Situation; as if one place
South Latitude 11 deg. 30 min. the other in
h Latitude 16 deg. 33 min. having difference
ongitude 109 deg. 35 min. Then take 109 deg.
in. out of 180 deg. there remains 70 deg. 25
for a new difference of Longitude; to which
North latitude 11 deg. 30 min. and South
ude 16 deg. 23 min. And find the true diſtance
ixt the two places laſt propounded, and work
it is done in the 18 Situation; and the true di-
ce is found there to be 74 deg. 59 min.
aſtly, Take the Diſtance 74 deg. 59 min. out
of

of 180 deg. and there remains 105 deg. 1 m. the
great Circle Diſtance betwixt the two place
propounded in this Situation , *viz.* One S
Latitude 11 deg. 30 min. the other South Lat.
23. having difference of Longitude, 109 d. 35 m
true diſtance (I ſay) is 105 d 1 min.

The reaſon why it muſt needs be ſo , is be
from any point in North Latitude, (in what de
and minute ſoever it be) to the oppoſite po
which is alwaies in the ſame deg. and min of S
Latitude, and 180 d. difference of Longitude f
the former point , is alwaies 180 deg. of diſta
from that former point.

Hence it is clear, if from any point of Latitude
great Circle, betwixt the two oppoſite points,
know the difference of Lon. to one of thoſe oppo
points, the complement of that Lon. to 180 d
is the difference of Longitude to the other. And
Diſtance from the point betweene the oppo
points, to one of the oppoſite points is the comp
ment of the Diſtance therefrom to the other op
ſite point. As from North Latitude 11 deg. 36 m
South Lat 16 deg. 23 m. The difference of Lon.
deg. 25 min. is diſtance 74 deg. 59 min. So by
Complements of Longitude and diſtance fr
South Latitude 11 deg. 30 min. to South Lat. 16
23 min. difference of Longitude 109 deg. 35 min.
diſtance 105 degrees 1 minute.

For Longitude $\begin{Bmatrix} 70. \ 25. \\ 109 \ 35. \end{Bmatrix}$ make 180 degrees.

So diſtance $\begin{Bmatrix} 74. \ 59 \\ 105. \ 1. \end{Bmatrix}$ is 180 degrees.

CHA

CHAP. IIII.

*the true Longitude and Latitude of
two places given , to finde the Obli-
quity of that great Circle that paſſeth
the neereſt way from the one to the o-
ther.*

Eeing it is clear that the Meridians are great
Circles, that have the greateſt Obliquity that
be. *viz.* 90 degrees. And that the Equator
Equinoctial Line is a great Circle that hath no
bliquity at all, theſe cutting each other at Right
gles; therefore there needs no more to be ſaid
ncerning the places that be both Situate under a
ridian, or both under the Equator , but that
ping under the Equator , the Rumbe is ever
rect Eaſt or Weſt, and under the ſame Meridian,
e Couſe is direct North or South.

Onely concerning the fifth Situation , this is to
noted , they being both under the ſame Me-
dian , and one having North Latitude , and
e other South Latitude of the ſame quantity.
hen the paſſage betwixt them may bee made
nder the ſame Meridian , direct North , or
outh. Or a great Circle may bee drawne

over

over both the places, that will interfect the
tor juft half way betwixt them , and the gr
Obliquity of that great Circle , is the quant
the latitude of each place ; (for they muft be in
Situation both of one quantity) and the prop
ded latitude of thofe places, is the greateft Ob
ty of that great Circle, the Meridian cutting
the very point of its greateft Obliquity ; which
vidently manifeft at the firft view , becaufe
latitudes be of the fame quantity: therefore the
terfection of the great Circle with the Equator
juft in the midft betwixt the two places, *viz.* 90
from each place, and each Obliquity.
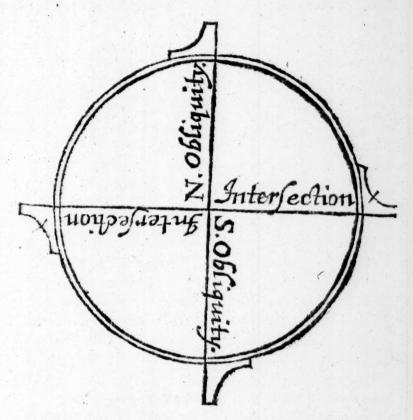
Now feeing all great Circles except Meri
and the Equator, are in many things like the
cliptick line; yet in two things they differ ,
are therefore Obfervable, and may be confider
in this place.

I. The Ecliptique line , alwaies (what-ev
the queftion concerning the places under it)
croffe or cut the Equinoctial line in the fame po
as in the head of and ♎.But thefe other great
cles may (it may be) for every Queftion , ha
different point of Interfection in the Equator;
the points of interfection, are alwaies oppofite
to another, as alfo the points of their greateft
liquity are 90 deg. diftant from thofe point
their Interfection, and are Diametrically oppo
one to another.

Yet in feverall queftions all thefe points m
have feveral places, as in the following Diagr
may evidently appeare.

To turn upon the Circle in pag 35. with a thred in the middle.

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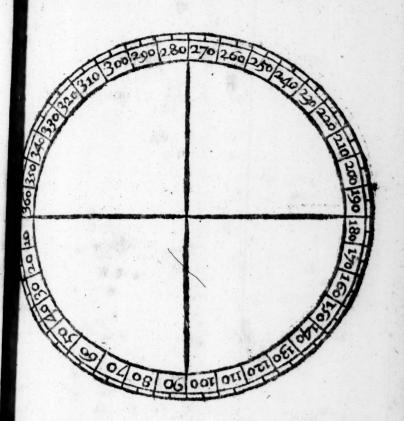
he Demonstration, in which the whole Circle
ongitude should be exactly graduated for this

you place the first Intersection at 10 deg. then
irst Obliquity is 100 deg. of Longitude , the o-
Intersection is at 190 deg. of Longitude , and
other Obliquity at 280 deg. thereof. And so
he known Longitude of any one of those points,
he rest are found, as also by adding 90 degrees,
degrees , or 270 degrees , or substracting so
<div align="center">D</div>
many

many degrees as the thing defired requires.

II. The Ecliptick line hath alwaies the fame quantity of Obliquity *viz.* 23 degrees 30 minutes. But the feveral great Circles may have feverall quantities of Obliquity, fome more, fome leffe according as the places propounded doe require.

And feeing that without the knowledg of the true quantity of the Obliquity of that great Circle which will paffe directly over the places propounded, there can be no compleat demonftration, much leffe Arithmeticall Calculation of things pertaining thereunto, as fhall more manifeftly appeare in the next Chapter;

Therefore it is neceffary that the true quantity of each great Circles Obliquity be diligently enquired after, and found out to exact certainty; which to doe, is in fome cafes very eafie, and in fome again more difficult.

I wil againe propound Rules for the feveral Situations of places before mentioned, except thofe that are Situate under the Equator, or under the fame Meridian.

Sit. 14. If one place hath no Latitude, and the other hath any quantity of Latitude, and the difference of Longitude betwixt them being leffe then 90 degrees. The obliquity of that great circle that will paffe directly over both thofe places is eafily found by this Rule. Firft, finde the diftance as in the former Chapter; Then, as the fine of the Diftance is to the fine of the Latitude; So is Radius to the fine of the Circles greateft Obliquity.

As

As one place Latitude 00 deg. 00 min. the other Lat. 11 deg. 30 min. the difference of Longitude 27 deg. 54 min. And the true diftance found to bee 30 degrees. Then,

As the fine of the found diftance 30 ^{d}. 00'. .969897

Is to the fine of the Latitude, 11. 30. 1929965

So is Radius (both thele together) —————

To the fine of the greatest Obliquity. 960068

So 13 degrees 30 minutes, is the greateft Obliquity of that great Circle extended over thefe two pla-ces.

Sit. 15. If one place hath no Latitude , and the other hath any quantity of Latitude, and the diffe-rence of their Longitudes be juft 90 degrees

Then it is evident to Reafon, and in the Diagram it may appear to the view, that one place is Situ-ate in the very point of the greateft Obliquity of that great Circle that will paffe directly over the faid places ; and the other place in the very point of the Interfection of the faid great Circle with the Equator. For it being in a Latitude 90 degrees from a point in the Equator , that quantity of La-titude muft needs alfo bee the greateft Obliqui-ty of that great Circle which paffeth over that La-titude and interfecteth the Equator 90 degrees therefrom.

Sit. 16. One place having no Latitude, and the o-ther having any quantity of Latitude, and the dif-ference of Longitude betwixt them being more then 90 degrees. To finde the Obliquity of the great Circle paffing over thofe places. Firft , finde the true great Circle Diftance betwixt the places , as is fhewed in the

prece-

precedent Chapter in this Situation; as one place Latitude oo deg. oo min. the other Latitude 11 deg. 30 min. difference of Longitude 152 deg. 6 min. Distance betwixt them is found there to be 150 degrees.

Then take the true great Circle Distance out of 180 deg. and there remains 30 deg.

Then, as the fine of the Remainder 30°.00'. 969897

    Is to the fine of the Latitude. 11. 30. 192996 5
    So Radius,   90. ————

To fine of the greatest Obliquity.   960068
So that 23 degrees 30 minutes is the greatest Obliquity of the great Circle extended over these two places.

Sit. 17. One place having North Latitude, and the other South Latitude, both of the same quantity and difference of Longitude lesse then 180 deg. (found as in Situation 10 and 13. in the former Chapter) The greatest Obliquity of the great Circle, that passeth directly over them, is found in this manner.

First, find the true distance betwixt them, as is shewed it should be done in the former Chapter, 17 Situation. As one place North Latitude 11 deg. 30 min. the other South Latitude 11 deg. 30 min. The difference of Longitude betwixt them being 55 deg. 48 min. The Distance 60 degrees: Divide the Distance betwixt them in two equall parts, and allow halfe the Distance to each Latitude. Then worke with halfe the Distance 30 degrees, and one Latitude 11 degrees 30 minutes.

As the fine of the true Diftance. 30^d. 00^1. 969897

Is to the fine of the Latitude. 11. 30. 1929995

So is Radius, 90. ————

To the fine of the Obliquity. 32. 30. 960068

Sit 18. One place having North Latitude , and the other place South Latitude of different quanti-ties, and the difference of their Longitudes being leffe then 90 degrees. As one place having North Latitude 11 degrees 30 minutes, the other South Latitude 16 deg. 23 min. the difference of Longitude betwixt them being 70 deg. 25 min.

Take both the Lat. as if they were both North or both South, and take the Complement of the dif-ference of Lon. to 180^d. which here is 109^d. and 35^1.

Then work by thefe foure Rules,

Rule 1. Adde the Latitudes together, and halve that fum for a mean Latitude. Alfo halve the dif-ference of Longitude betwixt them.

2. The true mean Latitude that ferves for this ufe, is fomething more then halfe the two Latitudes given, and the more difference there is betwixt the quantities of Latitude, the more muft be allowed for the mean Latitude.

3. To find this, trial muft be made fo often , as til by proof we know the true obliquity is found , which is the thing fought for.

4. When the obliquity found will give to each place its own Latitude , and alfo betwixt them both yield the true difference of Longitude given , then is found the true Obliquity of the great Circle that fhall paffe over the places propounded. As both the Latitudes 11^d. 30^1. and 16^d. 23^1. make 27^d. 53^1. And half the Lon. 109^d. 35^1. is 54^d. 47^1. 30^{11}.

half

Halfe both Latitudes is 13 deg. 56 min. 30ᵗ. bu
with a small addition count it 14 deg. 5 min. to
make a mean Latitude for this use.

As Radius to Cotangent of Lat 14ᵈ. 5′. 106005
So is Cosine of half the dif.of Lon. 54. 47. 30. 976083
To Cotangent of the Obliquity 23. 30. 1036137.
To try whether 23 deg. 30 minutes be the true O-
bliquity.

Rad. & Cotang. of Obliq. together 23ᵈ.30′.2036169
Take out Cotangent of Latitude. 16. 23. 1053169
Remaine Cosine of Longitude.   47. 27. 983004
Again Rad. Cotangent Obliquity. 23. 30. 2036169
Take out Cotang. other Latitude. 11. 30. 1069153

Remaine Cosine of Longitude.   62. 6. 967016
Then adde the Longitudes in both the operations
together, as 26 deg. 6 min and 47 deg. 27 min. they
make Lon. 109ᵈ. 33′. within two min. of the Lon.
last propounded, the complement of it is therefore
within two minutes of the Longitude first propoun-
ded, *viz.* 70 deg. 27 min.

Therefore we may conclude that 23 deg. 30′. is
the greatest obliquity of that great Circle that will
passe directly over two places, Situate, one South
Latitude 11 deg. 30 min. the other in South Latitude
16 deg 23 min. dif. of Longitude 109 deg. 35 min.
as also over two places, one North Lat 11 deg. 30
the other South Lat. 16ᵈ. 23′. difference of Lon.70
deg.25′. for these four places are all situate under
the same great Circle. The one Arch of distance
being the Complement of the other to 180 deg.

Again, If one place hath North Latitude 50
degrees, (as the Lizard,) and the other
                                            South

outh Latitude 35 deg. (as *Brazeel.*) and the difference betwixt their Longitudes be 58 degrees.

Take both their Latitudes as if they were North, or both South, and the complement of the diffe-rence of Longitude to 180 degrees, which here is 122ᵈ. Then work it by the four precedent Rules, halfe the Longitude is 61 deg. Both the Latitudes added together make 85 deg. halfe that is 42 deg. 30 min. I tryed Latitude 44 deg. found that too much, and 43 deg. 30 min. too little. So I found the true meane Latitude to find the Obliquity by, was 43 deg. 42 minutes, as I proved by this Ope-ration.

As Radius to Cotangent of Lat. 43ᵈ. 42ᶦ. 1001971
To Cosine of half dif. of Lon.   61. 00.   965557
To Cotangent of the Obliquity. 63. 6.   970528

Now to find whether 63 deg 6 min. bee indeed the true Obliquity, make these proofs of it.

Radius and Cotangent Obliquity. 63ᵈ. 6ᶦ. 970528
Take out Cotangent one Latitude. 50. 00. 99 381

Remains Cosine different Lon. 52.48. 973147
Again Rad. and Cotang. Obliq.   63 6. 970528
Take out Cotang. other Lat.   35. 00. 1015477

Remains Cosine different Lon.   69. 12. 985051

Now both the Longitudes found 69 deg. 12 min. and 52ᵈ. 48ᶦ. make just 122ᵈ. 00ᶦ. the difference of Lon-gitude at first propounded betwixt those two pla-ces; which proves that the greatest Obliquity of the great Circle that passeth directly over those two places so Situate, is 63 degrees 6 minutes. As also over *Lizard* and *Brazeel*, as before Situ-ate.

Sit 19. One Place having North Latitude, and the other South Latitude of different quantities and the difference of Longitude betwixt them being juſt 90 degrees. Concerning Places thus Situate proceed in this manner.

Firſt, find the Obliquity of the great Circle that paſſeth directly over thoſe places.

Secondly, find the great Circle Diſtance betwixt thoſe Places ; for in this Situation and the 23 it is referred to this Chapter, to find the great Circle diſtance.

As if one place have North Latitude 11 deg. 30 min. the other South Latitude 21 deg. 1 min. difference Longitude 90 deg.

Firſt, the Obliquity is found as in the precedent Situation 18. For half the difference of Longitude is 45 deg. and both the Latitudes 11 deg. 30'. and 21 d. 1'. make 32 deg. 31 min. half that is 16 deg. 15 min. 30''. But the mean Latitude that ſerves for this uſe, is about 17 deg. 5 min. Therefore I make tryal with it.

As Radius to Cotangent of Lat. 17 d. 5'.   1051240
So Coſine of half different Lon. 45. 0.   9849485

To Cotangent of Obliquity.   23. 30.   10361885
To prove this by the Longitude of each part of the Latitude , and adding the Longitudes together.

Radius and Cotangent of Obliq. 23 d. 30'. 20361885
Take out Cotangent of one Lat. 21. 1.   10415445

Remain Coſine of different Lon. 27. 53. 9946440
Taking the Obliquity in the ſame figures as I found it 2036188 adding Radius.

But

But If I take the number of Cotangent 23 deg. 30 min. adding Radius, then Longitude 27 deg. 55 min. may be found for that Latitude.

Again, Rad & Cotang of Obliq. 23ᵈ. 30'. 2036188
Take out Cotang. of the other Lat. 11. 30. 1069153

Remaine Cosine of dif. of Lon. 62. 5. 967035
Now both the Longitudes 62 deg. 5 min. and 27 deg. 53 min. make 89 deg. 58 min. that wants but two minutes of 90 degrees, or it is just 90 degrees, counting the one 27 degrees 55 min. as may be done.

Another Example.

One Place in North Lat. 40 degrees, the other in South Latitude 30 degrees, the difference of Longitude 90 degrees, half the Longitude is 45 deg. both the Latitudes make 70 degrees, half that is 35 deg.

I take 35 deg. 46 min. for the mean Latitude by which the Obliquity of the great Circle is found.

As Radius to Cotangent of Lat. 35ᵈ. 46'. 1014246
So Cosine of half different Lon. 45. 00. 984948

To Cotangent of Obliquity. 45. 32. 999194
Prove this by finding the Longitude to each Latitude propounded, *viz.* 40ᵈ. and 30 degrees.

Radius and Cotangent of Obliq. 45ᵈ. 32'. 1999194
Take out Cotangent of one Lat. 40. 00. 1007618

Remaine Cosine of Longitude. 34. 33. 991576.
Againe,

Radius and Cotangent of Obliq. 45ᵈ. 32'. 1999194
Take out Cotang. of other Lat. 30. 00. 1023856

Remaine Cosine of Longitude. 55. 29. 975338
Now Long. 34ᵈ. 33'. and 55ᵈ. 29 min. together,
make

make 90 deg. 2 min. Therefore the Longitudes agree, except 2 min. too much. And the Obliquity of the great Circle that passeth over those two places is 45 deg. 32 min.

2. Then to find the great Circle Distance betwixt places in this Situation.

Take the Complements of the Longitudes before found, each part by it self, and allow to each part the Latitude belonging thereunto, so shall the greater quantity of Latitude have the greater quantity of Longitude, that you may find the great Circle Distance, from the points of that great Circles Intersection, with the Equator, to the Latitude propounded. And those two Distances added together, make the true great Circle distance betwixt the places propounded. As in both these Examples.

One Place North Latitude 11 deg. 30 min. the other South Latitude 21 deg. 1 min. The Longitudes found were 27 deg. 54 min. and 62 deg. 5 min. Put them thus to find the distance from the Intersection.

As Radius to the Cosine of Lat. 11^d. 30^1. 999119
So is the Cosine of Longitude 27. 54. 994633

To Cosine of the Distance. 30. 00. 993742
And, as Rad. to Cosine of Lat. 21. 1. 997010
So is the Cosine of Longitude 62. 5. 967041

To the Cosine of the Distance. 64. 5. 964051

Then add the distances together 30^d. and 64^d 5^1. and they make 94 deg. 5 min. the great Circle Distance betwixt those 2 places.

The

The second Example.

One place North Latitude 40. the other South Latitude 30. The Longitudes found were, one, 55 degrees 29 minutes, the other 34 degrees 33 minutes, both are 90 degrees 2 minutes : becaufe there be two minutes too much, I wil abate in each Longitude one minute.

As Radius is to the Cofine of Lat.   40^d. 988425
So is Cofine of its Longitude   55 28   975349

To the Cofine of the Diftance.   64 16   963774
Again, as Rad. to Cofine Lat.   30^d.00. 993753
So is Cofine of its Longitude   34. 32. 991581

To the Cofine of Diftance.   44 29   985334
Then adde the diftances together 64 deg. 16 min. and 44 deg. 29 '. they make 108 deg. 45 minutes, which is the great Circle Diftance betwixt thofe places: For that in North Latitude 40 deg. is 64 deg. 16 min. diftant from the Interfection of that great Circle with the Equator; and that place in South Latitude 30 deg. is 44 deg. 29 min. diftant from the fame Interfection; fo both diftances make 108 deg. 45 minutes.

And thus you may find the Obliquity of the great Circle; fuch places are under that be in this Situation; and alfo find the great Circle Diftance betwixt them.

Sit. 20. One place having North Latitude , and the other South Latitude of different quantities, and the difference of Longitude betwixt them being more then 90.

As one place in North Latitude, 23 deg. 30 min.

the other in South Latitude 11 deg. 30 min. The difference of Longitude 117 deg. 54 min.   Then take the Complement of the difference of Longitude to 180 deg. which here is 62 deg. 6 min. and work with the Latitudes as if both were North, or both South.

B.   For if both the Latitudes be toward the same Pole, and the difference of Longitudes betwixt them be lesse then 90 degrees,   The Rule is,

1. As Radius is to the Cosine of the difference of Longitude, so is the Cotangent of the greater Latitude, To Tangent of the first Arch, which taken from the Complement of the lesse Latitude there remaines the second Arch.   Then,

2. As the Sine of the second Arch, is to the sine of the first Arch, so is the Tangent of the difference of Longitude to the Tangent of the direct Position.   Then

3. As Radius is to the Cosine of the lesse Latitude, So is the sine of the Angle of Position, to the Cosine of the great Circles greatest Obliquity.

1. This Rule will find the Obliquity, if one of the places propounded be in the very point of Obliquity. As in stead of the former places, one in North Latitude 23 d. 30'. the other in South Latitude 11 d. 30'. difference of Longitude 117 deg. 54 min.

H.   I propound two places both in North Latitude, one 11 deg. 30 min. the other 23 deg. 30 min. and difference of Longitude 62 deg. 6 min. the Complement of the other Longitude.   For the same great Circle is extended directly over all these places.   Then,

1. As

As Rad. to Cosine, difference Lon. 62 d. 8 . 967018
o Cotangent of greater Latitude. 23.30. 1036169

To Tangent of the first Arch.   47. 6. 1003187
ake 47 deg. 6 min. from 78 deg. 30 min. (the
omplement of 11 deg. 30 min.) there remain 3ɪ d.
4 min.

As sine of the second Arch 31 d. 24'. 971684.
To sine of the first Arch.   47. 6. 986483.
So Tangent of different Lon.   62. 6. 1027615
                                         2014098

To Tangent of Position.   69 d. 12 '. 1042414.
As Rad. to Cosine of less Lat. 11 d. 30 '. 999119
So sine of Angle of Position. 69. 22.   997120
To Cosine of the greatest Obliq. 23 d. 30'. 996239

2. If the point of Obliquity be betwixt the places
propounded. As,

If one place hath North Latitude 11 deg. 30 min.
the other place North Latitude 22 deg. 39 min. the
difference of Longitude betwixt them being 78 deg.
23 minutes.

1. As Rad. to Cosine, different lon. 78 d. 23 '. 930397
So Cotangent of the greater lat. 22. 39. 1037956

To Tangent of the first Arch.   25. 46. 968353.
Take this out of complement of less latitude 78 deg.
30 min. there remaines the second Arch. 52 deg.
44 min

2 As the sine of the second Arch 52 d. 44'. 990081
Is to the Sine of the first Arch   25. 46. 963819
So is Tangent of different lon.   78. 23. 1068703
                                              2032522

To Tangent of the Position   69. 23. 1042441
                                        3. As

3. As Rad. to Cofine of lefs Lat. 11ᵈ. 30'. 999119

So fine of the Angle of Pofition. 69. 23. 997129

To Cofine of the greateft Obliq. 23. 30. 996244

3. This Rule will alfo find the Obliquity, although both the places propounded be fhort of the point of Obliquity.

As one place North Latitude 11 deg. 30 min. the other in North Latitude 22 deg. 39 min. difference of Lon. 45 deg. 49 min.

1. As Rad. to Cofine dif. Long. 45ᵈ. 49'. 984320

So Cotangent of greater Lat. 22. 39. 1037956

To Tangent of the firft Arch. 59. 5. 1022276

Take that 59 deg. 5 min. from complement of lefs Latitude 78 deg. 30 min. There remains the fecond Arch 19 deg. 25 min.

2 As the fine of the fecond Arch 19 25 952170

Is to the fine of the firft Arch, 59 5 993344

So is the Tangent of different Lon. 45 49 1001238

 1994582

To Tangent of the direct pofition. 69ᵈ. 22'. 1042411

3. As Radius to Cofine of leffe Lat. 11 30 999119

So fine of the Angle of Pofition 69 22 997120

To Cofine of the greateft Obliq. 23 30 996239

Thus is the greateft Obliquity of the great Circle found, that paffeth over any two places, one having North Lat. and the other South Lat. and difference of Longitudes above 90 deg. by taking the complement of the difference of Longitude to 180 deg. and working therewith, and as if both the Latitudes were toward the fame pole.

Sit.

Sit. 21. Two places having both their Latitudes toward the fame pole , (whether both North , or both in South Latitude ,) their Latitudes being alfo of the fame quantity; And the difference betwixt their Longitudes, being leffe then 180 deg. (found as in Situation 10 and 13. in the former Chapter, is fhewed.) The greateft Obliquity of the great Circle that paffeth directly over thofe two places is found in this manner.

As if both places be in North Latitude 20 degrees 12 minutes, and have difference of Longitude 64 d. 24 m.

Firft, Divide the difference of Longitude into two equal parts , *viz.* 32 degrees 12 minutes. Then,

As Radius is to Cotang. of Lat. 20 d. 12 '. 1043423
So is the Cofine of half dif. of Lon. 2 12   992746

To Corang. of greateft Obliq.   23 30   1036169
I fay therefore , for two places having the fame quantity of Latitude toward the fame Pole; As Radius is to the Cotangent of the Latitude of the places , fo is the Cofine of halfe the difference of Longitude betwixt the places , To the Cotangent of the greateft Obliquity of that great Circle that paffeth directly over fuch places.

Sit. 22. Two places having Latitude toward the fame Pole , but of different quantitie , and the difference of Longitude betwixt their Meridians being leffe then ninetie degrees. The Obliquity of the Circle that paffeth directly over them is found by the Rule for this
very

very purpose in Situation 20. at *B* in the margent, and
the Examples at *H* and so forward there, where, if
one place be in North Latitude 11 deg. 30 min. the
other in North Latitude 23 deg. 30 min. The dif-
ference of Longitudue 62 deg. 6 min. the Obliqui-
ty of the great Circle passing directly over those
places, is found to be 23 deg. 30 min.

And such also is the Obliquity, if one place be in
North Latitude 11 deg. 30 min. the other North
Latitude 22 deg. 39 min. Difference of Longitude
78 deg. 23 min.

Againe, if one hath North Latitude 11 deg. 30
min. the other North latitude 22 deg. 39 min. dif-
ference longitude, 45 deg. 49 min. The Obliquity
is 23 deg. 30 min.

And if the latitudes were both South, and had
the same Difference of longitude (as in any of these
three Examples,) the Obliquity would be the same,
viz. 23 deg. 30 min. And so you may finde the Ob-
liquity for any two places in this Situation.

Sit. 23.   Two places having latitude toward the
same pole, (that is both North, or both South,) their
latitudes being of Different quantity, and having
Difference of longitude just 90 deg.

Firſt, finde the Obliquity of that great Circle
that passeth directly over both those places.

Secondly, find the great Circle Diſtance be-
twixt them; for that is referred to this Place.

Firſt, The Obliquity is found as is shewed in the
19 Situation. For in reference to the Obliquity of
the great Circle, it is all one whether the latitudes
be one North-ward, and the other South-ward, or
whether they be both North, or both South; So
that

that the Lon. of thofe Lat. that be both on the fame
fide of the Equator, be the complement Longitude,
Diff rence, to thofe that have Latitudes of divers
denominations, as North and South. As one place
in North Lat. 11 ᵈ. 30 ¹. the other North Lat. 21
deg. 1 min. D fference of Lon. 90 deg. 00 min.
The greateſt Obliquity of the great Circle extended
over two places, one in North Lat. 11 deg. 30 min.
the other South Lat. 21 deg. 1 min. dif. Lon. 90 deg.
is in Situation 19. found and proved to be 23 deg.
30 min. which is alfo the Obliquity of the great Cir-
cle paſſing over two places of the fame quantity of
Latitudes with thofe, both being North; as Latitude
11 degrees 30 min. and 21 deg. 1 min. and diffe-
rence of Longitude 90 deg.

And fo according to the other Example , one
place having North Lat. 40 deg. the other South
Lat 30 deg. difference of Longitude 90 deg the
Obliquity is there found and proved to be 45 deg.
32 min. So I conclude alfo that if one place hath
North Latitude 40 deg. and the other North La-
titude 30 degrees, difference of Longitude 90 deg.
the Obliquity is 45 deg. 32 min. and the working
and proving of it is the fame as is done there , and
fo any two places in this Situation.

2. The great Circle Diftance betwixt any two pla-
ces in this Situation, is found in the fame way , as
in the 19 Situation ; but taking alwaies the Com-
plement of the diftance there found to 180 degrees
for the true Diftance of places in this Situati-
on.

As in the firſt Example there. One place North
Latitude 11 degrees 30 minutes , the other South
E Lati-

Latitude 21 deg. 1 min. difference of Longitude
90 deg. the great Circle Diſtance there is found to
be 94 deg. 5 min.   Therefore,

One place in North Latitude 11 deg. 30 min. the
other in North Latitude 21 deg. 1 min. diffe-
rence of Longitude 90 degrees.   The Comple-
ment of 94 deg. 5 min. to 180 deg. *viz.* 85 deg. 55
min. is the true great Circle Diſtance betwixt thoſe
two places laſt propounded.

In the other Example there,

One place North Latitude 40 deg. the other
South Latitude 30 deg. difference of Longitude 90
deg. the great Circle Diſtance is there found to be
108 deg. 45 min.   Therefore,

One place in North Latitude 30 deg. the other in
North Latitude 40 d. difference of Longitude 90 d.
The Complement of 108 deg. 45 min. to 180 d. *viz.*
71 deg. 15 min. is the true great Circle Diſtance
betwixt the places laſt propounded.

And ſo the true Obliquity and diſtance betwixt
any two places in this Situation is found as in the
Operations in Situation 19. with the onely diffe-
rence of taking the Complement of the diſtance
found, as is before noted.

Sit. 24 Two places having Latitude toward the
ſame Pole, but of different quantities, and the
difference betwixt their Longitudes being more
then 90 degrees.

The Obliquity of the great Circle that paſſeth
directly over them is found by the four Rules in the
eighteenth Situation, and muſt be wrought as in the
Examples there.

As one place in South Latitude 11 deg. 30 min
th

the other in South Latitude 16 deg. 23 min. difference of Longitude 109 degrees 35 min. Both Latitudes 11 deg. 30 min. and 16 deg. 23 min. make 27 deg. 53 min, half both is 13 deg. 56'. 30''. but take for a mean Latitude 14 deg. 5 min. and half the Longitude is 54ᵈ. 47'. 30''.

(To find the sine of seconds, I added the sine of 54 deg. 47 min. to that of 54 deg. 48 min. in the three last places where they differed, and then took half of the numbers to the former. For the sine of 54 deg. 47 min. and 30 seconds.

As Rad. to Cotangent of Lat. 14ᵈ. 5'. 1060054
So Cosine of half dif. of Lon. 54. 47. 30. 976083

To Cotangent of the Obliquity. 23. 30. 1036137
To try whether 23 deg. 30 min. be the true Obliquity.

Radius and Cotangent of Obliq. 23. 30. 2036169
Take out Cotangent of one Lat. 16. 23. 1053165

Remaine Cosine of Longitude. 47ᵈ. 27'. 983004
Again, Rad and Cotang Obliq. 23ᵈ. 30'. 2036169
Take out Cotang. of other Lat. 11. 30. 1069153

Remain Cosine of Longitude. 62. 6. 967016
which is if you adde Longitude 47. 27. to Longitude 62 deg. 6 min. they make Longitude 109 deg. 33 min. which wanting but two minutes of the Lon. 109 deg. 35 min. at first propounded, therefore conclude that the true Obliquity of the great Circle that shall passe directly over those places is 23 deg. 30 minutes.

In the other example in Situation 18.

If one place be in South Latitude 50 deg. and the other in South Latitude 35 deg. having difference

ference of Longitude 122 deg. work it as it is don
there, where the mean Latitude to find the Obli
quity by, is 43 deg. 42 min. And the grea
Circle paffing directly over thofe two places
is found and proved to have Obliquity 63 degrees
6 minutes.

And a great Circle of the fame quantity o
Obliquity paffeth directly over two places. On
in North Latitude 50 degrees, the other in Sout
Latitude 30 degrees, having difference of Longitud
58 deg. as is beforefaid, for that thefe four place
laft mentioned, may bee all under one and th
fame great Circle. This is enough (I hope
and not too much to explain the Obliquity of grea
Circles.

CHAP. V.

How to make a true Paradoxall Chart, and
of many excellent ufes thereof, never
publifhed before this time.

1. ALthough the Coafts of Countries, and the
narrow Seas be both truly and lively defcri
bed in the common Sea-Chart, and it is moft eafie
to ufe, yet in many cafes it admits of monftrou
great errors in divers long voyages made to feve.
port
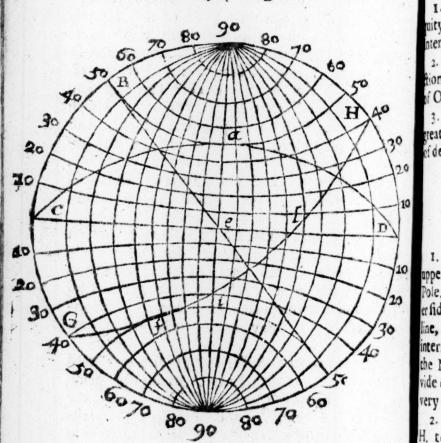
ports very farre diftant one from the other, and having very much difference both of Longitude, and Latitude.

2. And Mercators Plats being truely made, doe correct all, or moft of thofe errours, though by reafon of its different Scale or meafure, it doth not fhew the true and lively fhape (as I may fay) of the Country, or its Coafts to the view. But as they are neerer to either Pole, fo are they farre more extorted and ftretched beyond that lively proportion which they keepe neerer to the Equinoctiall Line. And yet doubtleffe Mercators Plats are the beft of all for Marriners ufe in all long voyages, its true ufe being well underftood, and diligently practifed, of which more afterward.

3. But the Paradoxall Chart following, which is a Sphericall Triangle in *Plano*, doth moft lively reprefent one eighth part of the Terreftriall Globe; and in it Arches of the great Circles extended from place to place, (mentioned before,) may bee truely demonftrated.

4. I know the Sphere may bee projected in *Plano*, by Circular lines, as in the generall Aftrolabe of *Gemma Frifius*, by the helpe of Tangents, and thefe great Circles extended from place to place (as before) may bee truely demonftrated by ftraight lines, being Semediameters to thofe great Circles; but in thofe Diagrams alfo 1 deg. in the outward Meridian is the

measure

meafure of 2 degrees about the Center, and very neer to it.

A Gemma Frifius Diagram.

Herein is defcribed a great Circle of 50 degrees Obliquity.

1, *B* ç *K* a ſtrait Diameter, ç Interſection. *B K* Obliquity.

2. *C* ç *D*

2. *C a D* an arch 10 deg. Longitude, *C D* Interfection *a* Obliquity.

3. *G fi l H.* an Arch 180 degrees Longitudes, Interfection. *f.* Obliquity.

1. The Circle B H K G is a Meridian of Obliquity. the perpendicular, **a e i** is a Meridian of Interfection.

2. The Circle BHKG is a Meridian of Interfection, and the perpendicular **a e i** is a Meridian of Obliquity.

3. The Circle BHKG is a Meridian cutting the great Circle of 50 degrees Obliquity, in its 40 deg. of declination.

1. *Concerning the making of a Paradoxal Chart.*

1. Make a Sphericall Triangle in *Plano.* Let the upper Angle mark with *H* reprefent the North Pole, (or if need require, the South Pole) the lower fide mark with B A. a quarter of the Equinoctial line, the fide B H the Meridian of the great Circles interfection with the Equator, and the fide A H the Meridian of the great Circles Obliquity. Divide every fide into 90 degrees, or at leaft mark every fifth degree in each fide.

2. Let a perpendicular line fall from the Angle H. to the middle (or 45 degrees) of the lower fide B A.

3. Divide that perpendicular line, by the meafure of the equal parts at every fifth degree, in one of the outward Meridians, as in B H. or A H. be-

ginning

ginning at the Equator, and proceeding upward.

4. Through thofe markes in the perpendicular line, to the marks for degrees of like number in the outward Meridians, draw Arches.

5 Divide each of thofe Arches into fo many equall parts as the quarter of the Equator below is divided into, which here is eighteene, that is, one for every fifth degree of Longitude.

6. Through thofe marks draw Meridians from the Angle H. the Pole to the Equator B A. at every fifth degree of Longitude.

7. By Arithmetick find the obliquity of great Circles paffing thorow every fifth degree of Latitude in the Meridian ; or (which is all one,) the perpendicular which falleth from H. to the 45 degrees (or middle) of the Arch B A. by this Rule.

As Radius is to the Cofine of the Longitude, So is the Cotangent of the Latitude, to the Cotangent of the Obliquity. As,

Radius to Cofine of Longitude, 45 ^{d}. 984948
So Cotangent of the Latitude. 45. 1000000

To Cotangent of the Obliquity. 54. 44. 984948

Shewing, that a great Circle of Obliquity 54 degrees 44 minutes, fhall cut the middle Meridian at Latitude 45. 00. So that having a Table of the Obliquities of the Circle that fhall cut the middle Meridian at every fifth degree of Latitude, the faid Meridian may be more exactly divided into degrees of true Latitude.

A Table of the Obliquity of the circles that will cut the middle Meridian at every fifth degree of Lat.

Lat.

Lat. deg.	Obliq. de. m.	Lat. deg.	Obliq. de. m.	Lat. deg.	Obliq. de. m.
5	7 3	35	45 17	65	71 45
10	14 0	40	49 53	70	75 34
15	20 45	45	54 44	75	79 16
20	27 14	50	59 19	80	82 54
25	33 24	55	63 39	85	86 27
30	39 14	14	67 48		

8. Then draw a ſtrait line from Angle B. to the
deg. of the Meridian of Obliquity marked A H.

9. Divide that ſtrait line into ſuch parts as
the degrees of Obliquity found Arithmetically do
require, reckoning thoſe degrees in the Equator,
that the Meridians croſſing the ſaid ſtrait line,
come from ſetting markes in the ſaid ſtrait line,
in a due proportionall quantity to thoſe Me-
ridians thorow which the ſaid ſtrait line paſ-
ſeth.

10. Then by the Diviſions of that ſtrait line,
divide the middle Meridian into true degrees of La-
titude.

11. Thorow thoſe Marks in the middle Meri-
dian draw Arches of true Latitude to the anſwe-
able degrees of Latitude in the outward Meridi-
ans.
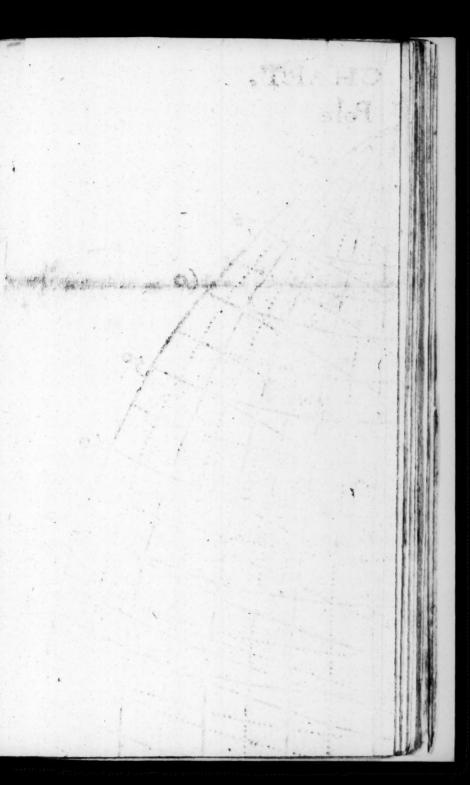
12. Then draw Arches of ſo many great Cir-
cles as you wil to their Obliquities; as to every tenth
or every fifth degree, and for Obliquity 23ᵈ. 30ʹ.
for the Ecliptick.

Note, Theſe Arches may beſt be drawne
in another Sphericall Triangle of the ſame
Magni-

Magnitude with the former, in another paper, juſt
in the ſame manner as the Meridians of this firſt
Triangle were made by the firſt 6 Rules herein pro-
pounded, and then pounſed or drawn into the firſt
made Sphericall Triangle, now made a Paradoxall
Chart, as here followeth an example of a Paradoxall
Chart.
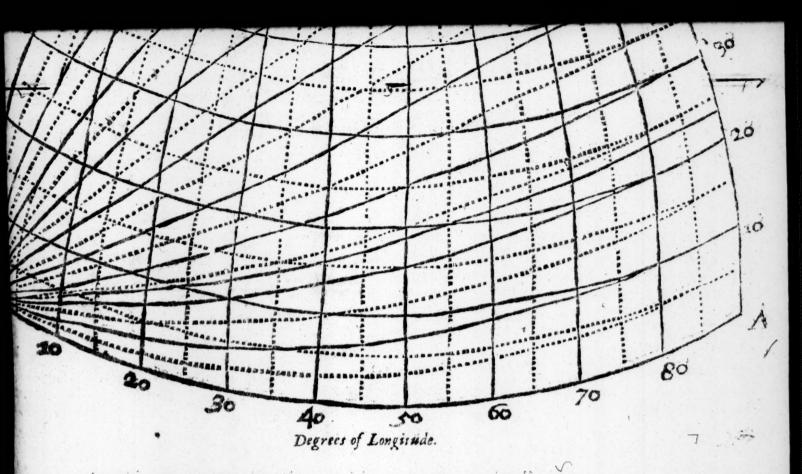
2. *Concerning the Uſes of the Paradoxal Chart.*

1. By the Paradoxall Chart thus made, you ha
examples of 17 great Circles more then ever I ſa
in any plat, before I made this, all notable for the
difference of Obliquity, and by which one m
draw lines upon Mercators Plats very neere the pa
ſage of the great Circle from place to place, if t
obliquity be the ſame with one of theſe Arches. A
one may gueſſe neer the truth in any other Ob
quity, theſe being but five deg. diſtant one fro
another.

2. Upon the Paradoxal Chart (made witho
thoſe Circles of Obliquity) may be drawn a
eighth part of the Terreſtrial Globe, more truly a
lively to the view, then any way elſe *in Plano*. (b
cauſe all places in it are neerer to one and the ſa
meaſure for diſtances, and yet keeping neerer the d
Longitude and Latitude then they do in any)
though it be not ſo fit for Sea mens uſe, as Merc
tors Plats be, becauſe the Rumbes cannot well
drawne hereupon for them to keep their reck
ning by.

3. Up

A PARADOXALL CHART.
The H Pole

80

80

70

70

60

60

50

50

40

40

40

40

30

30

30

20

10

Degrees of Longitude.

In this Paradoxall Chart, H. reprefents the Pole.

B H An Arch of that Meridian which cuts the Equator in the fame point that the great Circle Interfects it.

A H An Arch of that Meridian, in which is the point of the great Circles greateft Obliquity.

In both thefe Arches are figured degrees of Latitude. And from one fide to another, are drawne Parallels of Latitude, reprefented by the Arches betwixt them.

B A Reprefents a quarter of the Equinoctial Line.

And from the Angle B to the Arch A H are drawne a quarter of 18 great Circles. The other three quarters of them are eafily found by thofe.

Upon the Paradoxall Chart having the Arches
of 17 great Circles of Obliquity from the Angle B
to the Meridian A H. you may see what quantity
of Latitude any one of them passe thorow at any
quantity of Longitude required, as at 5 deg. 10 deg.
15 deg. or 20 deg of Longitude &c.

Or for any quantity of Latitude propounded, you
may see at what quantity of Longitude from the
intersection of that great Circle with the Meridian,
it will passe thorow the Latitude propounded, the
Obliquity of the same Circle must also be propoun-
ded.

4. The Chart it selfe is a scale of distance upon
the Arch of the great Circle, taking the extent with
the Compasses betwixt the Obliquity and one place.
As from the Obliquity at 60 deg of Latitude, till
that arch come into Latitude 40 deg. which is 61 ^{d}. of
Longitude from the Meridian of the Obliquity, and
apply that extent to the Meridian at Longitude 60.
setting one foote in the Equator, the other
upward in the same Meridian, there shall you find
the distance to be 42 ^{d}.

And the same way may you measure the distance
on any great Circle from the Obliquity, by the
same extent of the compasses applyed to the Me-
ridian of the same number of degrees with the O-
bliquity. And the complement of that Distance to
90 degrees is the distance thence to the Angle of
Intersection A. so from the Angle A in the great
Circle of 60 degrees Obliquity to Latitude 40 deg.
is distance 48 deg. the Complement of 42 deg. the
distance before found.

5. Having the true Latitude of the place, and

its Longitude from the Obliquity , or fro
the point of the Circles Interfection wi
the Equatuor , one may by this Chart
finde very neere the true quantity of that gre
Circles Obliquity , and of the great Circl
Diftance from that Obliquity , as Latitu
40 degrees Longitude from Obliquity 61 d
grees. The Obliquity is; found 60, Diftan
42.

6. Having the Latitude and the differen
of Longitude propounded betwixt two place
fituate in the fame quantity of Latitude towa
the fame pole , by this Chart one may find nee
the Obliquity of the great Circle that paffe
from one of thofe places to the other , and ve
neere tell the true great Circle Diftance betwi
them. As two places in North Latitude 40 d
grees, difference of Longitude 122 degrees ; ha
the Longitude is 61 degrees. Thereby you m
eafily find the Circle that cuts the Latitude 4
degrees at that diftance from the Obliquity Me
ridian , comes to the Obliquity at 60. and is diftan
thence 42 degrees (as was before fhewed) which
doubled (becaufe the Longitude was halved be
fore) is 84 degrees , the diftance betwixt thofe tw
places.

7. Having the Obliquity and great Circl
Diftance betwixt two places, they being bot
in one Latitude (the quantity of Latitude no
propounded ,) to find the Latitude of the pla
ces , and the difference of Longitude betwi
them. As the Obliquity of the Circle betwix
two

wo places both in one Latitude is 60 degrees
he Diſtance betwixt them 84 degrees ; Then
ake halfe the Diſtance 42 degrees, being mea-
ured in the Meridian of 60 degrees of Lon-
gitude, becauſe the Obliquity propounded is
60 degrees. And applying that extent to the
Meridian of Obliquity in the Circle from 60
degrees toward Angle B. it will reach to the
Arch of 40 degrees of Latitude, (being the
Latitude of both the places required,) and bee
61 degrees from the Meridian of Obliquity,
which being doubled (becauſe you halved the
Diſtance before,) makes 122 degrees diffe-
rence betwixt the Longitudes of thoſe pla-
ces.

8. One place being propounded with its La-
titude, being known to bee in the Obliquity,
and the great Circle Diſtance to another place
given.

As one place in Latitude and Obliquity 60 de-
grees, another place 42 degrees of Diſtance in
the great Circle therefrom. As before you may
ſhde the Latitude of the place required is 40
degrees, the difference of Longitude 61 degrees.

9. If one place bee propounded under the
Æquator, the other in any Latitude given,
with the Difference of Longitude betwixt
their Meridians, then the Obliquity of the great
Circle, and the great Circle Diſtance betwixt
them, may bee found thus. As Latitude 40 deg.
the difference of Longitude 29 deg. Look therefore
in Latitude 40 degrees, what great Circles paſſe tho-
row

row it 29 deg. from the Meridian of Interfection
B H. and it is one that goes to Obliquity 60 de
and the diftance (as before is fhewed) from th
Obliquity 60 deg. to Latitude 40 deg. in this Ci
cle 42 deg. the complement thereof about 48 de
is the diftance required, and 60 deg. the Obliquit

10. If one place hath North Latitude, and th
other South Latitude of the fame quantity, the di
ference of Longitude betwixt their Meridian giv
to find the great Circles Obliquity, and the gre
Circle Diftance betwixt them, as one in South L
titude 40 deg. the other in North Latitude 40 de
difference of Longitude 58 deg. Take half the Lo
gitudes difference, *viz.* 29 deg. and one Latitude
and work it as in the precedent example, and bein
done, double the diftance, fo the Obliquity of th
great Circle is 60 deg. and the diftance about
deg.

11. The Obliquity of the great Circle, and tw
places in feveral Latitudes propounded, to find
it the great Circle diftance and difference of Long
tude betwixt them. As in the Obliquity 60 de
one place in Latitude 40 deg. the other in Latitu
51 deg. then from the Obliquity to Latitude 40 de
is found the diftance 42 deg. (as before) in li
manner from the Obliquity 60 deg. to Lat. 51
is found Diftance 26 d. Now 42 deg. and 26 de
make 68 deg. the diftance of one place from the
ther. And Latitude 40 deg. hath Longitude 61
from the Meridian of Obliquity (as is found befor
and the place in Latitude 51 deg. hath 45 degre
of different Lon. therefrom; and 61 d. added to 4
they make difference of Lon. 106 d. betwixt the fa
places.   12. Th

2. The Obliquity of the great Circle, and two degrees in several quantities of Longitude from the Circles of Intersection with the Equator (which is alwayes the complement to 90 degrees of difference of Longitude from the Meridian of its Obliquity) propounded. The Latitude of each place may be found, and the great circle distance betwixt them.

Two places under the great circle that hath Obliquity 60 deg. One hath difference of Longitude from the Meridian of Intersection 29 deg. the other difference of Longitude therefrom 45 deg.

Now if you mark the Arch of Obliquity 60 **deg.** you shall see that 29 deg. from the Meridian B H. it crosseth Latitude 40 deg. and again 45 deg. therefrom it cutteth Latitude 51 deg. so that I conclude the place is in Latitude 40 deg. the other in Latitude 51 deg. Then take (in the same great circle) as before the Distance from the Obliquity 60 deg. to the place in Latitude 40 deg. which is 42 deg. and in the same manner the distance from the Obliquity 60 deg. to the place in Latitude 51 ^{d}. which is 26 deg. Now if the Meridian of Obliquity came betwixt the places propounded , so that on the Globe , one place tended from the Obliquity Eastward, and the other Westward , then both the distances 42 deg. and 26 deg. must be added together, and make the true Distance 68 ^{d}. as in the precedent work.

2. But if from the Meridian of Obliquity both places be in the Arch tending to one and the same point of Intersection : Then take the lesse Distance 26 deg. out of the greater 42 ^{d}. and there remains the true distance betwixt them 16 deg.

3. But

3. But if the Meridian of Interſection come
twixt the places, and ſo one place hath Nor.h L
tude, the other South Latitude. Then both th
ſtances, *viz.* 42 deg. and 26 deg. muſt be added
gether, and they make 68 deg. which 68 deg.
out of 180 deg. and there remains the diſta
112 degrees , and that is but 22 minutes m
then the exact diſtance betwixt two places ſo ſ
ate.

Many like queſtions may be propounded for g
paſtime and profit , anſwered with ſpeed and
light, yeelding much intelligence in great C
Sayling, as coming to the truth, or very neer i

But if two places of different quantities of L
tude be propounded, and the Obliquity of the g
Circle be not given, the anſwer will be more d
cult and uncertain; yet thoſe that have conven
time to practiſe theſe things (which I have not)
do delight therein, may find out much matter b
uſeful and pleaſant. I recommend it therefore
them for fit Recreation.

And any Obſervable thing found thereby m
be tryed by the exact working of the Queſtion
the Arithmetical Rules contained in this Book.

And thus much or rather thus little concerni
the Paradoxall Chart, uſeful even above the o
nion of moſt men.

C H A

CHAP. VI.

How by Arithmetick to calculate exactly for any Degree and Minute of Obliquity, what Degree and Minute of Latitude the great Circle shall passe thorow, for any degree and minute of Longitude from the point of Obliquity, or of its intersection with the Equator. Whereunto is annexed a Table of the degrees and minutes of the Latitude of the great Circles for every five degrees of Obliquity, and the Obliquity of the Ecliptick line for every five degrees of Longitude from the Intersection of the great Circles, with the Equator or Ecliptick Line.

THe Obliquity of the great Circle being given, you may calculate exactly the degrees and min. Latitude it passeth thorow for any degree and minute of Longitude from the Meridian of the Circ. Obliquity or Intersection with the Equator by these two Rules.

F   1. Whe

1. What Difference of Lon. foever any point of place hath from the Meridian of its next Obliqu t which is ever 90 deg. or leffe, the Compleme thereof to 90ᵈ. is the difference of Lon of th point or place from the Meridian of that great Ci cles next Interfection with the Equator.

As in the Circle of Obliquity 60ᵈ. a point in L 40ᵈ. is Longitude from the Meridian of Obliqui 61 deg. the Complement of 61 deg. to 90ᵈ. is 29 which is the Longitude of that point to the Me dian of Interfection.

2. As the Cofine of the Difference of Longitu from the Obliquity ,
Is to the Cotangent of the Obliquity.
So is Radius
To the Cotangent of the Latitude.
Example, *Lizard* in North Latitude 50 deg. T Summer Ifles , or *Barmodas* North Lat. 32ᵈ. 29 difference of Lon. betwixt their Meridians 70ᵈ. T great Circles Obliquity 50ᵈ. 34 min.

To find thorow what deg. and min. of Lat. t great Circle paffeth for any deg. and min. of diff rence of Longitude from the Meridian paffi through the great Circle in the point of its great Obliquity,   Ufe the fecond Rule thus.

Rad. and Cotang. of Obliq. 50ᵈ. 30'. 199150
Take out Cofine, dif. Longit. 58. 31. 9717

Remain Cotang. of Latitude   32. 25. 10197
The Latitude 32 deg. 25 min. of *Barmodas.* Th
Rad. and Cotangent of Obliq. 50 34. 199150
Take out Cofine of dif. Lon. 11ᵈ. 29'. 9991

                                                      Rema

A TABLE of Eighteene GREAT CIRCLES, viz. One

for every five degrees difference of Obliquity, as in Columne B H. And one at 23 deg. 30 min. of Latitude for the Ecliptick circle, with the Degrees and Minutes of the *Latitude* of each of those 18 circles, for every five deg. of *Longitude*, to be reckoned from the point of the Intersection of each of those circles with the Equinoctial Line, as from A to B. or from C to H. The upper and nether lines, with these figures 90, 85, 80, 75 &c. shew so much Longitude from the Intersection aforesaid. And the complement of any of them, as 00, 5, 10, 15, 20, &c. shew the Longitude from the Obliquity. The lines betwixt those two, shew the deg. and min. of Latitude to each Obliquity and Longitude abovesaid.

85	80	75	70	65	60	55	50	45	40	35	30	25	20	15	10	5	A
84 56	84 59	84 49	84 40	84 29	84 14	83 54	83 29	82 57	82 15	81 19	80 5	78 24	75 39	71 20	63 16	44 53	
79 57	79 51	79 39	79 23	78 59	78 30	77 51	77 2	76 00	74 40	72 55	70 34	67 21	62 44	58 44	44 34	26 18	
74 57	74 47	74 29	74 5	73 32	72 48	71 53	70 43	69 15	67 45	64 55	61 49	57 39	51 55	44 00	32 57	18 1	
69 56	69 43	69 21	68 50	68 7	67 12	66 3	64 33	62 46	60 28	57 36	53 57	49 16	43 13	35 26	25 31	13 28	
64 55	64 40	64 14	63 37	62 26	61 42	60 21	58 40	56 36	54 2	50 53	46 59	42 11	36 15	29 2	20 25	10 35	
59 55	59 37	59 8	58 26	57 30	56 19	54 50	53 00	50 46	48 4	44 48	40 54	36 12	30 39	24 9	16 44	8 35	
54 54	54 35	54 4	53 19	52 19	51 2	49 20	47 35	45 17	42 33	39 19	35 32	31 6	26 2	20 17	13 56	7 6	
49 54	49 34	49 1	48 14	47 12	45 54	44 19	42 24	40 7	37 27	34 25	30 48	26 44	22 10	17 9	11 41	5 56	
44 54	44 34	44 1	43 13	42 11	40 54	39 19	37 27	35 16	32 44	29 50	26 34	22 54	18 55	14 31	9 5	4 59	
39 54	39 34	39 2	38 15	37 15	36 00	34 30	32 44	30 41	28 20	25 42	22 45	19 32	16 1	12 15	8 17	4 11	
34 54	34 35	34 4	33 21	32 24	31 14	29 50	28 13	26 21	24 14	21 53	19 18	16 29	13 28	10 16	6 56	3 30	
29 54	29 37	29 9	28 29	27 57	26 33	25 18	23 51	22 13	20 21	18 20	16 6	13 43	11 10	8 4	5 44	2 53	
24 55	24 40	24 15	23 40	22 55	22 00	20 55	19 39	18 15	16 41	14 58	13 7	11 9	9 4	6 53	4 38	2 20	
23 25	23 11	22 47	22 13	21 31	20 38	19 36	18 25	17 5	15 37	14 00	12 16	10 25	8 28	6 25	4 19	2 10	
19 56	19 43	19 23	18 53	18 18	17 30	16 36	15 35	14 26	13 10	11 48	10 19	8 57	7 6	5 23	3 37	1 49	
14 57	14 47	14 31	14 8	13 39	13 4	12 23	11 36	10 44	9 47	8 45	7 38	6 28	5 15	3 58	2 40	1 20	

A TABLE of Eighteene GREAT CIRCLES, viz. One

for every five degrees difference of Obliquity, as in Columne B H. And one at 23 deg. 30 min. of Latitude for the Ecliptick circle, with the Degrees and Minutes of the *Latitude* of each of those 18 circles, for every five deg. of *Longitude*, to be reckoned from the point of the Intersection of each of those circles with the Equinoctial Line, as from A to B. or from C to H. The upper and nether lines, with these figures 90, 85, 80, 75 &c. shew so much Longitude from the Intersection aforesaid. And the complement of any of them, as 00, 5, 10, 15, 20, &c. shew the Longitude from the Obliquity. The lines betwixt those two, shew the deg. and min. of Latitude to each Obliquity and Longitude abovesaid.

85	80	75	70	65	60	55	50	45	40	35	30	25	20	15	10	5	A
84 56	84 59	84 49	84 40	84 29	84 14	83 54	83 29	82 57	82 15	81 19	80 5	78 24	75 39	71 20	63 16	44 53	
79 57	79 51	79 39	79 23	78 59	78 30	77 51	77 2	76 00	74 40	72 55	70 34	67 21	61 44	58 44	44 34	26 18	
74 57	74 47	74 29	74 5	73 32	72 48	71 53	70 43	69 15	67 45	64 55	61 49	57 39	51 55	44 00	32 57	18 1	
69 56	69 43	69 21	68 50	68 7	67 12	66 3	64 33	62 46	60 28	57 36	53 57	49 16	43 13	35 26	25 31	13 28	
64 55	64 40	64 14	63 37	62 26	61 42	60 21	58 40	56 36	54 2	50 53	46 59	42 11	36 15	29 2	20 25	10 35	
59 55	59 37	59 8	58 26	57 30	56 19	54 50	53 00	50 46	48 4	44 48	40 54	36 12	30 39	24 9	16 44	8 35	
54 54	54 35	54 4	53 19	52 19	51 2	49 29	47 35	45 17	42 33	39 19	35 32	31 6	26 2	20 17	13 56	7 6	
49 54	49 34	49 1	48 14	47 12	45 54	44 19	42 24	40 7	37 27	34 25	30 48	26 44	22 10	17 9	11 41	5 56	
44 54	44 34	44 1	43 13	42 11	40 54	39 19	37 27	35 16	32 44	29 50	26 34	22 54	18 55	14 31	9 5	4 59	
39 54	39 34	39 2	38 15	37 15	36 00	34 30	32 44	30 41	28 20	25 42	22 45	19 32	16 1	12 15	8 17	4 11	
34 54	34 35	34 4	33 21	32 24	31 14	29 50	28 13	26 21	24 14	21 53	19 18	16 29	13 28	10 16	6 56	3 30	
29 54	29 37	29 9	28 29	27 57	26 33	25 18	23 51	22 13	20 21	18 20	16 6	13 43	11 10	8 4	5 44	2 53	
24 55	24 40	24 15	23 40	22 55	22 00	20 55	19 39	18 15	16 41	14 58	13 7	11 9	9 46	5 34	3 8	2 20	
23 25	23 11	22 47	22 13	21 31	20 38	19 36	18 25	17 5	15 37	14 00	12 16	10 25	8 28	6 25	4 19	2 10	
19 56	19 43	19 23	18 53	18 18	17 30	16 36	15 35	14 26	13 10	11 48	10 19	8 57	7 6	5 23	3 37	1 49	
14 57	14 47	14 31	14 8	13 39	13 4	12 23	11 36	10 44	9 47	8 45	7 38	6 28	5 15	3 58	2 40	1 20	
9 58	9 51	9 40	9 24	8 58	8 41	8 13	7 42	7 7	6 28	5 47	5 4	4 16	3 27	2 36	1 45	00 53	
4 59	4 56	4 50	4 42	4 32	4 20	4 5	3 50	3 33	3 13	2 53	2 30	2 7	1 43	1 18	00 52	00 26	
85	80	75	70	65	60	55	50	45	40	35	30	25	20	15	10	5	C

emain Cotangent of Latitude. 50^d. 0^1. 992386
he Latitude 50^d. of the *Lizard*.

And by this Rule is the Table mentioned in the
ontents of this Chapter made, which is here infer-
d,and eafie to underftand by the few Directions
ritten in it.

> { Infert here the Table of
> { eighteene great Circles.

And by the fame Rule, I made this Table of an
ch of a great Circle extended from Lat. 32^d.25^1.
Lat.50^d. difference of Lon.70^d. fetting the point
Obliquity upon a Meridian line, that fo it might
the better protracted on a Paradoxall Chart, or
rcators Plat.

.Lon. on Ob.	Lat. de. m	dif. Lon. fromOb.	Lat. de.m.	dif. Lon. fromOb.	Lat. de. m.
rmodas		35	44 53	5	50 24
58 31	32 25	30	46 29	Obliq.oo	50 34
55	34 54	25	47 47	5	50 24
50	38 1	20	48 50	11^d. 29^1.	50
45	40 41	15	49 35	Lizard.	
40	42 58	10	50 8		

CHAP.

CHAP. VII.

The Use of Mercators Plats being truel
  mado, and how the great Circle extende
  from place to place may be drawn there
  upon.   And how it may be demonstrate
  upon the same Plat, that an Arch
  the great Circle leads indeed the neere
  way beewixt places of any great quanti
  of Distance.

THe Mercators Plats (so called) being ma
  according to Mr. *Wrights*, Mr. *Gunters*, or
Norwoods Rules, are very usefull in Navigation
long Voyages, wherein also great Circle Sayling
most requisite.

For when you would make a voyage from
place to another far distant, you should mind w
ther the Arch of the greatCircle extended betwe
the places propounded, hath convenient Sea-roo
for if the great Circle betwixt the two places p
seth over land, or other inconvenient, dangero
or innavigable places, then you must make yo
voyage so neer the great Circle way, as with con
nience may be.

                                    Therefo

Therefore for any two places (being at the entrance into the great Ocean, as the *Lizard*, and the like ,) propounded, having found as before, the Obliquity of the great Circle that passeth betwixt the places, you may then demonstrate the same great Circle, as in the Paradoxall Chart, and thereby you may perceive thorow what Longitudes and Latitudes that Circle passeth. But more exactly are those Longitudes and Latitudes found by the Rule in the sixth Chapter, as in the Table for every fifth degree of Longitude and Latutide appeareth.

And having one Quadrant Paradoxall , or rather , a Table for a quarter of the great Circle, that Quadrant, or quarter, all the rest, or any portion more of the same great Circle, may be laid down in a true Mercators Plat.

And Note,

1. The Mercator Plats when true, have the divisions of degrees of Latitude in the Meridian Line , increasing larger and larger , as the Latitude is more and more distant from the Equator. So that from Latitude 55 deg. to 65 deg. (being but 10 deg. difference of Latitude) is as wide a distance with 20 deg. of Longitude, or 20 deg. of Latitude, if taken from 10 deg. of South Latitude to 10 deg. of North Latitude upon the same plat.

2. And when it is made compleat, it hath a scale thereby to measure Leagues in all the severall Latitudes in the Plat , by applying the Compasses to the Latitude figured in the Scale, as proper to that Latitude in which the Distance is to be measured ; similitude of which Scale you have in the blank

Mercator

Mercator hereunto annexed. And when you woul
meaſure a Diſtance in the lat. of 40ᵈ. then appl
the Compaſſes to that line in the ſcale figured 4
deg. &c.

As for a great Circle whoſe greateſt Obliquity
60 deg. The Paradoxall Chart, for every 5 deg
of Lon. gives neer thoſe Latitudes which are
the Table for that purpoſe. As theſe following
for every 10 deg. of Longitude reckoning fro
the Interſection to the Obliquity of the grea
Circle, *viz.*

for $\begin{cases} 10. & 20. & 30. & 40. & 50 & 6 \\ 16.44. & 30.39. & 40.54. & 48.5. & 53.0. & 56.1 \end{cases}$

for $\begin{cases} 70. & 80 & \text{degrees of Longitud} \\ 58.26. & 59.37. & \text{degrees and min, of Lati} \end{cases}$

Then in the preſent Mercators Plat, H. ſtandin
at the 60 degrees of North Latitude, and B. ju
90 degrees of Longitude Weſtward by the Equa
tor, and A. 90 deg. Eaſtward from H, but 180
from B, by the ſame Equator.

In every Meridian therefore betwixt B and H
and A and H. (one Meridian being drawn at
very ten degrees of Longitude) make a mark at th
Latitude found in the Table, (the Latitudes ſ
every tenth degree having a parallel line, and
the outward Meridian the degrees are divided
and numbred) and having ſo marked every Me
dian betwixt B and A. Then by thoſe markes yo
may draw Arches, which ſhal repreſent the Arch
the great Circle, paſſing over the places propou

d under a Circle of that Obliquity, or it may
ffice, though they be right lines drawne from
ark to mark, as from the Intersection of the Me-
dian and Equator at B. draw a line to a mark in the
ext Meridian, and from that to the mark in the
ext &c. to H. and thence again in like manner to

So have you half a great Circle, whose Ob-
liquity is 60 deg. North (and the like is the decli-
nation of the same Circle South) laid down in a
Mercators Plat.

And being so laid down, you may (according
to the usual way) find the Rumbe to be sailed on,
either by drawing Rumbs on the Plat, or by a
Portractor; or else the Plat being (by Parallels
of equal measure one from another, and equal to
the Distance of the Meridians) all put into true
squares, in some convenient spare place or pla-
ces; one or two, or four of those squares, ha-
ving a quarter of the Compasse, with the Points and
quarter of points, exactly divided, and marked
in two sides of the same square; then may one
suddenly transferre any point or quarter of a
point out of that square into any of the squares
in the plat, with a paire of Compasses, ta-
king the extent of the point required in the
quarter of Compasses out side, and applying
it to the side of any Square else. Or drawing a
dark strait line by which you are to saile it, or its
parallel cutting the Angle of the square in the
side of the Square (which the line cuts short of
the opposite Angle to that it came from)

take

take the extent and apply it to the outside of the
quarter of Compasse, where you may find the
point and its quarters.

And this I conceive, if well understood, is the
best way, but any true way, that one hath
long used, is best to him. So the Rumb from B. to-
ward H. for 20 deg. of Longitude, and 30 degrees
39 min. of Latitude is found two points and three
quarters of a point from the North Eastward, and
so you may find the Rumbe elsewhere.

And the Distance is found in a Mercators Plat
if it be truely made (and wants a Scale, such a one
as I mentioned before,) by setting the Compasses,
one foot in one place, and the other foot in the
other place, betwixt which 2 places you would
know the Distance, and apply that Distance to the
outside Meridian, as far above the upper Latitude,
as beneath the lower Latitude (the quantity above
and beneath if need be, may be measured equall
one to another, with another paire of Compasses.)
Then shall the number of degrees in the said Meri-
dian, betwixt the feet of the first paire of Com-
passes, being reckoned each degree 20 Leagues, and
after that quantity for any part of a deg. shew the
Distance betwixt the places so measured. So the
Distance from Longitude 00 and Latitude 00. to
Longitude 20 deg. Latitude 30 deg. 39 min. is about
36 deg. or 720 leagues.

In like manner I have portrayed on this Merca-
tors Plat, a great Circle Arch from *Barmudas* to
Lizard, one being in North Latitude 32 deg. 25
minutes, the other in North Latitude 50 deg. with
difference of Longitude 70 d. from the mark ☉ un-
der

er R. to the mark ⊙ under T. and the Obliquity
the Circle is in the Meridian by S. which Voyage
Mr. *Norwood* hath largely defcribed in his Seamans
practife, and in his Doctrine of Triangles.

Alfo that you may when you pleafe, make trial
of any of the examples that are propounded under
the Eclipttick line, I have drawn a portion thereof
fo large as may ferve for moft of the Situations
belonging to the fame, whether both be toward the
fame Pole, or one place North-ward Latitude, the
other South-ward of the Equator. All which
things being treated of by others (in reference to
the ufe of Mercators Plat) and being eafie to be
underftood, I fhall let them fo paffe.

2. Now that the great Circle doth direct the neer-
eft way from place to place, one being far diftant
from the other, is evident by Mercators Plat itfelf.
As in the precedent Plat. Two places both in
North Latitude 40 deg. having difference of Lon-
gitude 122 deg. the great Circles Obliquity being
in Latitude 60 deg. The neereft paffage from one
of thofe places to the other, is by Latitude 60 deg.
in the midft of the voyage, as is cleared by the
Plat thus,

In Latitude 40 deg. from *e* to *f* keeping in that
parallel, being 122 degrees of Longitude, is 5612
miles, for in that Latitude 46 miles anfwer to a de-
gree in Longitude.

And it is about the fame diftance alfo, meafured
by the fcale that fhould be made with Mercators
Plat, taking 50 leagues, or 100 out of the line
proper to Latitude 40. and therewith to meafure
the diftance in the Parallel. Or if there want fuch

a fcale

a Scale , then open the compasses from *e* halfe
way to *f*, in that parallel , and apply that extent
to the Meridian line that is graduated , as
much above the parallel of 40 degrees , as below
the fame , and you shall find the Distance to bee
such as is said before.

But now measuring in the great Circle , from
e in the Latitude 40 deg. by H in the Latitude 60
deg. to *f* in the Latitude 40 deg. you shall find
the distance that way to be much less then so ; for
if there be a Scale to your plat , take off 50 leagues
out of the line marked 50. because that is the mid-
dle parallel Latitude betwixt 40 deg. Lat. and 60
deg. of Latitude.

Or if you have no scale in your Mercators
Plat , then in the Meridian line open your Com-
passes , and set one foote in the parallel of 40
degrees, extend the other foot *e* to the parallel
of 60 degrees (because betwixt these two La-
titudes, the Voyage from *e* to *f* is to be made)
and that is the Distance of 20 degrees , or 400
Leagues for that Voyage (or rather opening
the Compasses from Latitude 50 deg. to 40 deg.
first, and with that 10 deg. to measure the parts
of the aforesaid Arch betwixt those two Lati-
tudes ; And then open them from 50 deg. Lati-
tude to 60 deg. upon a Meridian line, and with that
Distance of 10 deg. measure the other part of the
same Arch from 50 deg. to 60 deg. and to 50
deg. again or) with that extent of 20 degrees
(your Compasses open thereto) see how many
times 20 degrees there is in the Circle from *e* by
H to *f*. and that I find to be about 57 degrees

But

But if the Plat were a large one and more exactly made, the distance is not so much: for the true great Circle Distance taken Arithmetically is but 84 deg. 8 min. And that is but 5048 miles for the exact great Circle Distance indeed betwixt the two places *e f.* and that is almost 600 mile a neerer way then to keep in the parallel of Latitude 40 deg. But if wee count upon 87 degrees Distance taken in this Mercators Plat (for want of a larger and truer,) it comes to 5220 miles Distance, and that is 392 miles neerer then to keep in the parallel of Latitude 40 degrees all the way.

The Reason is, because the great Circle alwayes inclines to the Pole, and there the degrees of Longitude are shorter, and therefore the measure in Mercators Plats are longer. For 10 deg. in the Parallel of Latitude 60 deg. is as long a measure as 20 deg. in the Equator.

CHAP.

CHAP. VIII.

How to keepe a true Reckoning of the Voyage by the Latitude well observed, and the Rumb discreetly rectified. And to find the Latitude, Rumbe, Longitude and Distance, (having two of them known) by many Arithmeticall Rules. And how to prick the same downe in a Blank Chart or Mercators Plat.

HAving a true and large Mercators Plat of the Seas and parts adjacent wherein, and neer to which your intended Voyage is (if God please) to be made. And you find it convenient and advantagious to saile from one place to the other, by an Arch of a great Circle, the Plat discovering no land, rocks, sands, nor any other impediments to hinder you in that way, you also having found by the Rules before, the Distance betwixt the places, according to an Arch of the great Circle, and the greatest Obliquity thereof.
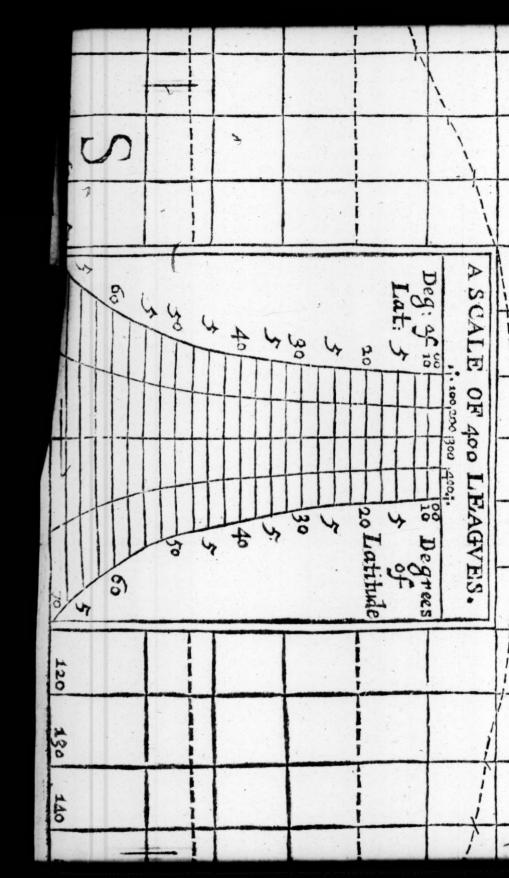
Take a sheet of Leasse paper, of the best, or more if need be, or a sheet of Parchment if you please, and make a Blank Chart, and line it with parallel
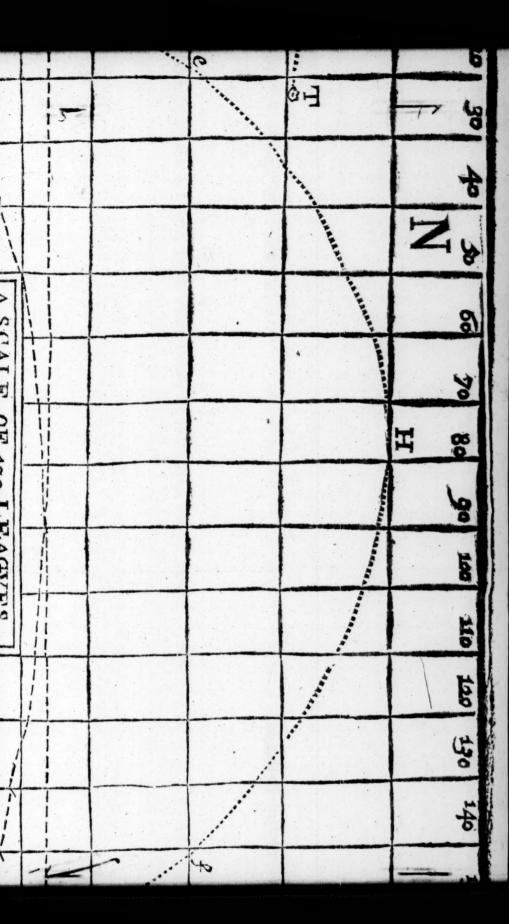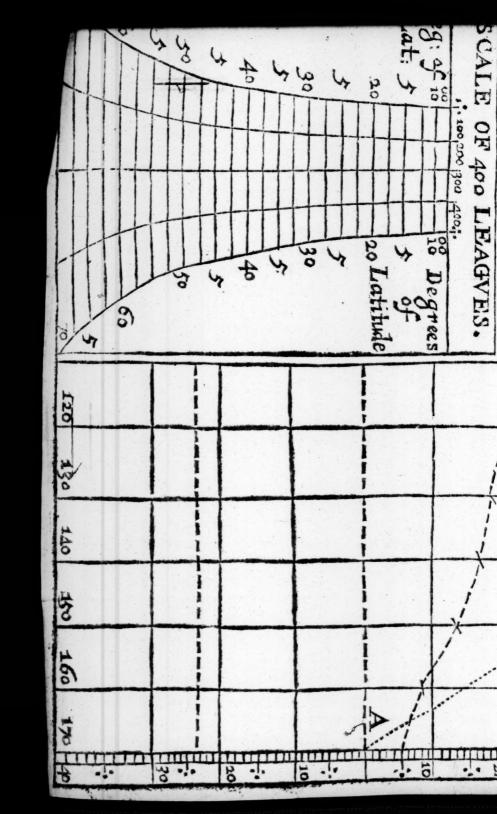
20

W

10

10

20

30

B

S

A SCA

Deg: 3
Lat:

30 R ⊙ 40 50

R
W
M
B
S.

1
2
3
4

8 7 6 5

360 10 20 30 40 50 60

S

T

e

N

A SCALE OF 400 LEAGVES.

Deg: of Lat:

Degrees of Latitude

S

120 130 140

3° 4° 5° 6° 7° 8° 9° 10° 11° 12° 13° 14°

N

H

T

e

SCALE OF 400 LEAGVES.

1. 100 200 300 400.

g: 25 40
at: 5

10
20
5
30
5
40
5
50
5
5
10 Degrees
5 of
20 Latitude
30
5
40
5
50
5
65
70
5

120 130 140 150 160 170

40
30
20
10

A
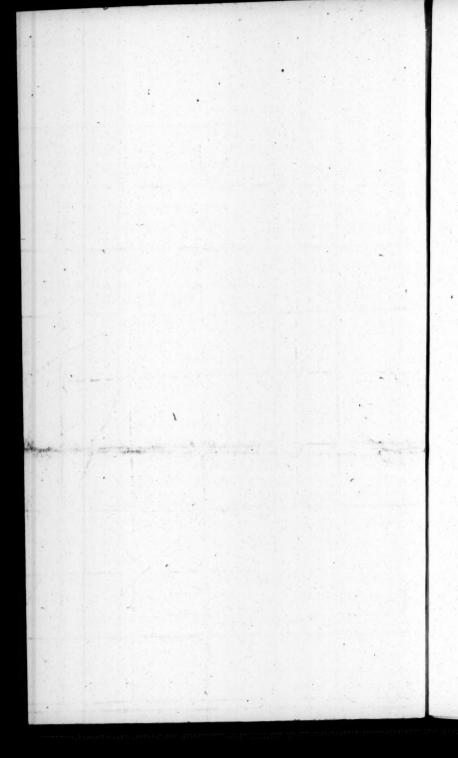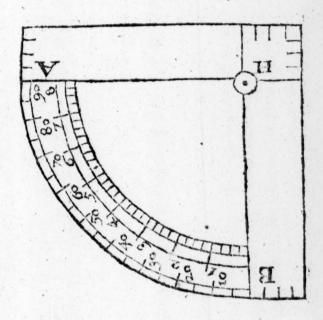
This to turn upon the Figure betweene page 78. and age 79 by a thred in the rundle.

allel lines (after the manner of that I have put into his book) of the same measure for degrees of Lat. as they be in your Mercator, although it be but of such a part of your Mercators Plat, as is necessary to keep your reckoning upon for that Voyage. So shall the parallel lines, and the Meridians (when they be drawn thereon,) be the same distance one from another as those lines be in the Plat for that Latitude. For then by the Scale in your Plat, or by the Meridian line of your Plat, you may measure Distances in your Blank.

I come now to propound divers Arithmeticall Rules for your more certaine and exact direction how to keep your reckoning upon your blank, and pricking it truely down thereon.

And these Rules contain direction,

1. How to trace out the Arch of a great Circle betwixt the places in the blank Chart.

2. How to know at first, and also afterward, what Rumb you are to sail upon, keeping in, or neer the same Arch of a great Circle.

3. How to know the Longitude and Latitude you are in after some progresse made in your Voyage.

4. I shall adde some direction about pricking the place downe in your Blank Chart.

The Rules of the first sort are these.

By the Latitudes of two places, the difference of Longitude betwixt them, and the Obliquity of the great Circle passing directly over both places given, To find the difference of Longitude of each place from the Meridian of the greatest Obliquity.

As North Latitude 32 deg. 25 min. and North
Lat.

Latitude 50 deg. difference of Longitude 70 deg.
Obliquity 50.34.

Rule 1. Work firſt with the leſs quantity of Latitude to find the difference of Lon. belonging to it.

Rad. and Cotangent of Obliq. 50 d. 34 '. 1991507
Take from it Cotang. of leſs Lat. 32. 25. 1019720

Remain Coſine of dif. of Lon. 58. 31. 971787

Rule 2. Take the dif. of Lon. found by the leſſe Lat. out of the whole dif. of Lon. propounded at firſt and there ſhall remain the difference of Lon. belonging to the greater Latitude. As 58 d. 31 '. taken out of 70 d. there remain 11 d. 29 '. for the dif. of Lon. betwixt the place in Lat. 50 deg. and the Meridian of the greateſt Obliquity.

The uſes of theſe Rules are,

1. To find where (in the Blank Chart) to place the Meridian of Obliquity, for the beſt advantage to trace out the Voyage, ſeeing we find it muſt be at leaſt 58 d. 31 '. of Lon. from one ſide of the Plat, and 11 d. 29 '. of Longitude from the other ſide thereof.

2. To find what dif. of Lon. is betwixt the Obliquity, and any Latitude propounded.

Rule 3. By the Obliquity of the great Circle, and the difference of Longitude from the Obliquity.

To find the true Latitude.

Rad. and Cotang. of Obliquity. 50 d. 34 '. 1991507
Take from it Coſine of dif. Lon. 11. 29. 999121

Remains Cotangent of Latitude. 50. 00 992386

Thus may one find thorow what Latitude the great Circle paſſeth every 10 deg. or 5 deg. more or leſſe quantity of Longitude from the Obliquity, and thereby know at what Latitude to make marks.

rks in every Meridian, and so to trace out the great Circles Arch in your Blank Plat.

Rule 4. By the Latitude and difference of Longitude from the Obliquity, to find the true great Circle distance.

Radius to Cosine of Latitude. 50^d. 00^1. 980806
is the sine of the dif. of Lon. 11. 29. 929903
to the sine of the Distance. 7^d. 21^1. 910709

7^d. 21^1. Is the great Circle Distance from the point of greatest Obliquity of that Circle.

Rule 5. By the Obliquity of the great Circle, to find the true Latitude to any quantity of great Circle Distance from the point of its greatest Obliquity.

As the Obliquity 50 deg. Distance 46^d. 3^1.
Rad. to sine of greatest Obliq. 50^d. 34^1. 988782
is Cosine of dist. from Obliq. 46. 3. 984137
to the sine of the true Latitude. 32^d.25^1. 972919

Rule 6. By the great Circle distance from the point of Obliquity, and the Lat. given, To find the difference of Longitude betwixt that place, and the Meridian of greatest Obliquity.

Radius and sine of dist. from Obliq. 46^d.3^1.1985729
Take from it the Cosine of the Lat. 32.25. 992643

Remain the sine of dif. of Lon. 58.31. 993086

By these 3 latter Rules you may gather further instruction and confirmation in your former work of tracing the great Circle by Lon. Lat. and distance from the point of its greatest Obliq.

Note, That the Complement to 90^d. of the great Circle Distance of a place from the point of the great Circles Obliquity, is alwaies the great Circle distance from that point wherein that Circle Interecteth the Equator.
The

The Rules of the second sort.

Whereby to find what Rumb you are to saile o[n]
that you may keep in, or neer unto the Arch o[f]
great Circle extended from one place to the othe[r]

Rule 7. By the difference of Longitude from t[he]
Obliquity, and the Latitude given, to finde t[he]
great Circle Distance from the point of Obliquity

As Radius to sine of dif. Lon $\left.\right\}$ 58^d. 31^l. 99308[.]
from the Meridian of Obliq. $\left.\right\}$

So is the Cosine of the Latitude 32. 25. 99264[.]

To sine of great Circle Distance. 46. 3. 98572[.]

Rule 8. By the great Circle Distance from the O[.]
bliq. and the Latitude given to find the Rumb.

Radius and Tangent of the $\left.\right\}$ 46^d. 3^l. 200159[.]
great Circle Distance. $\left.\right\}$

Take out Cotangent of Lat. 32. 25. 1019726[.]

Remain Cosine of Rumbe.   48. 48. 98187[.]

Having therefore found the Distance betwixt th[e]
two places by the Arch of a great Circle, and tha[t]
Circles greatest Obliquity, as is shewed in the thir[d]
and fourth Chapters of this book, you may by th[e]
first and second Rules of this Chapter find the di[f]
ference of Longitude of each place from the poi[nt]
in the great Circles greatest Obliquity. And the[n]
by these seven and eight Rules find the great Circl[es]
distance to the Obliquity, and the Rumb to be sa[i]
led on from either place toward the other.

Note. By the Rumb is meant the number of de
grees and minutes from the Meridian which you ar[e]
to sail upon, which being divided by 11 deg. 15 m[.]
the quotient shews how many points they be. O[r]
you may see by this Table.

A Table of the Points of Compasse, and quarters,
with their degrees and minutes.

Points.		deg.	min.	Points.		deg.	m.
o. N. or S.		00	00.	4. NE. or NW.		45	00.
quarter	1.	2	48	quarter	1	47	48
	2.	5	37		2	50	38
	3.	8	26		3	53	27
. N. by E.		11	15	5. NE by E.		56	15
quarter	1	14	3	quarter	1	59	04
	2	16	52		2	61	53
	3	19	41		3	64	42
. NNE		22	30	6. ENE		67	30
quarter	1	25	18	quarter	1	70	19
	2	27	7		2	73	8
	3	30	56		3	75	57
. NE by E		33	45	7. E by N.		78	45
quarter	1	36	33	quarter	1	81	34
	2	39	22		2	84	23
	3	42	11		3	87	12
. NE		45	00	8. E or W		90	00

Putting West for East, and South for North (a let-
ter standing for the word, N North, S South, E East,
W West.) This Table serves the whole Compasse.

Rule 9. By the great Circle Distance , and the
difference of Latitude given to find the Rumbe.
Radius and sine of dif. of Lat.   6ᵈ. 20'.   1904262
Take out sine of the Distance.   10. 00.   923967

Remain Cosine of the Rumbe.   50. 34.   980295
                          G   The

The leſſe Latitude taken from the greater, the Remainer is the difference of Latitude. As Latitude 32 deg. 25 min. taken out of Latitude 38 deg. 45 min. there remains 6 deg. 20 min. the difference of Latitude.

Rule 10. To find how far a man ſhould Saile upon a Rumbe before hee change his courſe a point, halfe a point, or a quarter of a point, let him try that in his blanke Plat (made by a true Mercator plat,) where the voyage is carefully traced out as before.

Or he may try Arithmetically every point, or quarter of a point, as hee ſeeth cauſe, or rather at each half point by this Rule.

Having found by the eighth Rule, the Rumbe was 48 deg. 48 min. put it to a halfe point, or neer it 50 degrees, 34 minutes. And then,

Rad. and ſine of the dif. Lat. 6^d. 20'. 1904262
Take out Coſine of the Rumbe, 50. 34. 980289

Remain the ſine of the Diſtance, 10. 0. 923973
And 10 degrees is 200 leagues.

Therefore 10 degrees, or 200 leagues may bee ſailed from Latitude 32 degrees 25 min. upon the Rumb 50 deg. 34 min.

Now to make proof of this Arithmetically, uſe theſe Rules.

Rule 11. By the Rumb, and Diſtance upon it given, to finde the difference of the Latitudes.

As Rad to Coſine of the Rumb, 50^d. 34'. 980298
So is the ſine of the Diſtance 10. 00. 923967

To ſine of the differe⸗nce of Lat. 6. 20. 904265
　　　　　　　　　　　　　　which

which 6 degrees 20 minutes , added to the former Latitude 32 degrees 25 min. make the Lat. 38 deg. 45 min.

Rule 12. By the Obliquity of the great Circle, and the Latitude given , to find the difference of Longitude from the Meridian of Obliq.

Rad. and Cotang. of Obliq.   50ᵈ. 34′. 1991507
Take out Cotang. of the Lat.   38. 45.   1009550
_____

Remains Cosine of the dif. Lon. 48. 42. 981957
Therefore that place is Latitude 38 degrees 45 min. and 48 deg. 42 min. difference of Longitude from the Obliquity.

Rule 13. By the Latitude and difference of Longitude from the Obliquity given ; to finde the great Circle Distance from the point of Obliquity.

As Rad. to Cosine of the Lat.   38ᵈ. 45′. 989203
So is the sine of the dif. of Len.   48. 42.   987579
_____

To sine of the Distance,   35. 52.   976782
Which 35 deg. 52 min. (the great Circle Distance from Latitude 38. 45.) taken out of great Circle Distance from Latitude 32 deg. 25 min. to the point of Obliquity, *viz.* 46 deg. 3 min. there remaine but 11 min. which is a small losse (I conceive) in 200 leagues, by sayling somewhat out of the great Circle.

Then you may proceede to the Rumb next to be sailed on.

Halfe a point more is N E by E. or 56 deg. 15 min. and the difference of Latitude 2 deg. 47 min. (which you may find, or neer it in your Plat.)

G 2   Then

Then worke by the tenth Rule. Or rather, by the
Diftance upon the Rumbe (found in the Plat) by
the 11 Rule.

As Rad. to Cofine of Rumbe 56 d. 15 '. 974473
So is the fine of the Diftance 5. 00. 894029
To the fine of the dif. of Lat. 2. 47. 868502
which 2 d. 47 min added to the Lat. next before
found 38 d. 45 m. It comes to Lat. 41 d. 32 min. for
this place.   And fo proceed in the reft, as before.

Rule 14. When you are come neer to the Lati-
tude of the Obliquity, fteer away Eaft or Weft , as
neer as you can, the Diftance found by this Rule. Or
if you find the Place you would fail to, be neer the
Lat. of the greateft Obliq. (as the *Lizard* in this
example is) then keep in that Latitude that the
faid place is in, and look out timely and diligently
for it.

But to know what diftance you are to fail, in that
Parallel of Latitude. By the Latitude , and the
difference of Longitude given, to find the Diftance
upon a courfe Eaft or Weft.

As Radius is to the Cofine of Latit. 50 d. 980800
So is the fine of the dif of Longit. 25 d. 9 '. 962837
To the fine of the true diftance. 15. 51. 943643
which 15 deg. 51 min. being converted into leagues
make 321 leagues.

The Rules of the third fort.

Wherein is fome direction for the knowledge of
the Longitude and Latitude after progreffe made in
the voyage.

Rule 15. By the difference of Latitudes, and the
Rumb failed on, to find the Diftance.

Radius

Radius and fine of dif. of Lat.   6. 20.   1904262
Take out Cofine of the Rumbe.   30. 34.   980289
Remains the fine of diftance.   10. 00.   923973
The dift. is then 10 deg. or 280 leagues

This Rule is of great ufe at Sea, for the Latitude taken by exact Obfervation, and the Rumb (the Variation of the Compaffe difcreetly allowed,) are the two fureft meanes whereby a Marriner may make his conclufion moft certain.

Rule 16. By the Latitude, and the diftance failed upon an Eaft or Weft courfe, to find the difference of Longitude.

As 20 leagues failed in Lat. 51 deg. 30 min.
Radius and fine of Diftance   1 d. 00'.   1824185
Take away Cofine of the Lat.   51. 30.   978414
Remain fine of difference of Lon.   1. 36.   844751
Therefore failing 20 leagues Eaft or Weft, in the parallel of 51 deg. 30 min. the difference of Lon. thereby made is 1 deg. 36 min.

This Rule is of ufe in great Circle failing, when they be neere the Obliquity, or neer the end of the Voyage, they being in the Latitude of the Haven they aime at.

Rule 17. Having both the Latitudes of two places, and the Obliquity of the great Circle they ftand in; to finde the difference of Longitudes betwixt thofe two places. As the Obliquity of the great Circle 50 d. 34'. One place in Lat. 32 d. 25', the other in Lat. 38 d. 45'. both Latitudes North. This is done at 2 operations (as in Rule 12) and deduction thus,
1. Rad. and Cotang. of Obliq.   50 d. 34'.   1991507
Take out Cotangent of Lat.   38. 45.   1009550

Remain

Remain Cosine of dif. Lon.	48.	42.	98195
2. Rad. and Cotang. of Obliq.	50.	34.	199150
Take out Cotangent of Lat.	32.	25.	101972
Remain Cosine of different Lon.	58.	31.	97178
3. Then out of the greater difference of Lon.	58ᵈ.	31'	
Take the lesser difference of Longitude.	48.	42.	

There remaines difference of Longitude. 9. 49.
The true difference of Longitude betwixt the two places propounded.

Rule 18.   Make your voyage as farre from the E-quator, as the great Circle will permit , for that is the neerest way, and so going and returning be-twixt the same places , must be thorow the same quantities of Latitude and Longitude the same way, upon the contrary points of Compasse.   Onely be sure you come into the Lat. of the place you saile unto, rather a little too soon, then to be too late, lest you should overshoot the place, and so misse it . yet get not into the Latitude of that place you go to, too soon, for you loose way thereby.

4.   Lastly, Concerning the pricking down in your Plat, the places as you are in the Voyage.

Though you may as often as you think meete, prick down in your Blank Chart , the place you find the ship to be in (but doe it not too often in your Mercators Plat, for spoiling of it ;) yet I would have you keep a strict accompt of your Voy-age, as Mr. *Norwood* in his Seamens Practise doth direct you, in fair writing.   And so daily (or of-ten) add Latitude to Latitude , and Longitude to Longitude.   Or substract one of them from the other, as may agree with the truth of your voyage.

For

or Lat. increafeth in failing toward either Pole, and decreafeth as you fail neerer and neerer to the Equator. Again, Longitude increafeth from the Prime Meridian (placed at Michaels Iland , toward the Eaft,) till you come to its beginning again, and decreafeth failing Weftward by the fame reafon. Keep (I fay) your reckoning both of the Latitudes and Longitudes Arithmetically for exactneffe ; for oft times the very points of the Compaffes in prick-ing the Plat, make a fmal error, which being oft ad-ded to (by feverall times doing it,) may in time make a great fault. And continue in this practife, to the end of your voyage , and every time you prick down the place in the plat , mind both its meafured Diftance from the Situation , or place pricked down next before it ; and alfo mark how it agrees with your Arithmeticall accompt of Lon-gitude and Latitude , and if need require , rectifie it by the fame. If it doth not neede any amend-ment, there is much confirmation thereby , befide the Practife will doe thee much good ; for (believe me) thefe few directions, as homely as they bee (for I have not time to trick them up) will ren-der failing both by Mercators Plat, and alfo by an Arch of a great Circle, more eafie then moft men can think for , fo that any Sea-man that can ufe his plain Chart with underftanding, may, ap-plying his mind to thefe things , and trying to practife the fame, (firft in the very queftions and examples herein,) attain to a Competent know-ledg of the moft neceffary things pertaining to Na-vigation ; and the ufe of the Canon of Artifi-ciall Sines and Tangents, both in Queftions of

Aftro-

Aſtronomie and Geometrie, as wel as in Naviga-
tion.

Accept of my good will; I have uſed much
plaineneſſe of ſpeech, that thou
mayeſt underſtand it, and reap
profit, and yeild GOD
the Glory.

FINIS.